4.2 Surface Water and Sediment Surveillance

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Surface water and sediment on and near the Hanford Site are monitored to determine the potential impacts of Hanford-originated radiological and chemical contaminants to the public and to the aquatic environment. Surface-water bodies included in routine surveillance are the Columbia River, riverbank springs, onsite ponds, and irrigation water at the Riverview irrigation canal. Sediment quality surveillance is conducted on the Columbia River and riverbank springs. Tables 4.2.1 and 4.2.2 summarize the sampling locations, types, frequencies, and analyses included in surface-water and sediment surveillance activities during 1996. Sample locations are identified in Figure 4.2.1. This section describes the surveillance effort and summarizes the results for these aquatic environments. Detailed analytical results are reported by Bisping (1997).

Columbia River Water

The Columbia River is the second largest river in the continental United States in terms of total flow and is the dominant surface-water body on the Hanford Site. The original selection of the Hanford Site for plutonium production and processing was based, in part, on the abundant water supply offered by the river. The Columbia River flows through the northern edge of the site and forms part of the site's eastern boundary. The river is used as a source of drinking water for onsite facilities and communities located downstream from the Hanford Site. Water from the Columbia River downstream of site operations is also used extensively for crop irrigation. In addition, the Hanford Reach of the Columbia River is used for a variety of recreational activities, including hunting, fishing, boating, water-skiing, and swimming.

Originating in the mountains of eastern British Columbia, the Columbia River drains a total area of approximately 70,800 km^2 (27,300 mi^2) en route to the Pacific Ocean. The flow of the river is regulated by 3 dams in Canada and 11 dams in the United States, 7 upstream and 4 downstream of the site. Priest Rapids Dam is nearest upstream and McNary Dam is nearest downstream from the site. The Hanford Reach of the Columbia River extends from Priest Rapids Dam to the head of Lake Wallula (created by McNary Dam) near Richland. The Hanford Reach is the last stretch of the Columbia River in the United States above Bonneville Dam that remains unimpounded.

Flows through the Hanford Reach fluctuate significantly and are controlled primarily by operations at Priest Rapids Dam. Annual flows of the Columbia River below Priest Rapids Dam over the last 77 years have averaged nearly 3,360 m^3/s (120,000 ft^3/s) (Wiggins et al. 1995). In 1996, the Columbia River had exceptionally high flow; the annual average flow rate below Priest Rapids Dam was 4,500 m^3/s (160,000 ft^3/s). The peak monthly average flow rate occurred during June (6,700 m^3/s [240,000 ft^3/s]) (Figure 4.2.2). The lowest monthly average flow rate occurred during October (2,800 m^3/s [98,000 ft^3/s]). Daily average flow rates varied from 1,800 to 7,900 m^3/s (63,000 to 280,000 ft^3/s) during 1996. As a result of fluctuations in discharges, the depth of the river varies significantly over time. River stage may change along the Hanford Reach by up to 3 m (10 ft) within a few hours (Dresel et al. 1995). Seasonal changes of approximately the same magnitude are also observed. River-stage fluctuations measured at the 300 Area are only approximately half the magnitude of those measured near the 100 Areas because of the effect of the pool behind McNary Dam (Campbell et al. 1993) and the relative distance of each area from Priest Rapids Dam. The width of the river varies from approximately 300 to 1,000 m (980 to 3,300 ft) along the Hanford Site.

Pollutants, both radiological and nonradiological, are known to enter the Columbia River along the Hanford Reach. In addition to direct discharges of liquid effluents from Hanford facilities, contaminants in groundwater from past discharges to the ground are known to seep into the river (McCormack and Carlile 1984, Dirkes 1990, DOE 1992a, Peterson 1992). Effluents from each direct discharge point are routinely monitored and reported by the responsible operating contractor; these are summarized in Section 3.1, "Facility Effluent Monitoring." Direct

Table 4.2.1. Surface-Water Surveillance, 1996

Location	Sample Type	Frequency[a]	Analyses
Columbia River - Radiological			
Priest Rapids Dam and Richland	Cumulative	M Comp[b]	Alpha, beta, lo ^{3}H,[c] gamma scan, ^{90}Sr, U[d]
	Particulate (filter)	Q Cont [e]	Gamma scan, Pu[f]
	Soluble (resin)	Q Cont	Gamma scan, ^{129}I, Pu
Vernita Bridge and Richland	Grab (transects)	Q	lo ^{3}H, ^{90}Sr, U
100-F and 300 Areas	Grab (transects)	A	lo ^{3}H, ^{90}Sr, U
100-N Area	Grab (transects)	A	Alpha, beta, lo ^{3}H, ^{90}Sr, U, gamma scan
Old Hanford Townsite	Grab (transects)	A	lo ^{3}H, ^{90}Sr, U
Columbia River - Nonradiological			
Vernita and Richland[g]	Grab	Q	NASQAN, temperature, dissolved oxygen, turbidity, pH, fecal coliforms, suspended solids, dissolved solids, specific conductance, hardness (as $CaCO_3$), P, Cr, N-Kjeldahl, Fe, NH_3, $NO_3 + NO_2$
	Grab (transects)	Q	ICP[h] metals, anions, volatile organics
	Grab (transects)	A	CN, Hg
100-N, 100-F, and Old Hanford Townsite	Grab (transects)	A	ICP metals, anions, volatile organics, Hg
300 Area	Grab (transects)	A	ICP metals, anions, volatile organics
Onsite Ponds			
West Lake	Grab	Q	Alpha, beta, ^{3}H, ^{90}Sr, ^{99}Tc, U, gamma scan
B Pond	Grab	Q	Alpha, beta, ^{3}H, ^{90}Sr, gamma scan
Fast Flux Test Facility Pond	Grab	Q	Alpha, beta, ^{3}H, gamma scan
Offsite Water			
Riverview Irrigation Canal	Grab	3[i]	Alpha, beta, ^{3}H, ^{90}Sr, U, gamma scan
Riverbank Springs			
100-B, 100-K, 100-N, and 100-H Areas	Grab	A	Alpha, beta, ^{3}H, ^{90}Sr, ^{99}Tc, U, gamma scan, ICP metals, anions, volatile organics
100-D Area	Grab	A	Alpha, beta, ^{3}H, ^{90}Sr, ^{99}Tc, U, gamma scan, ICP metals, anions, volatile organics
Old Hanford Townsite and 300 Area	Grab	A	Alpha, beta, ^{3}H, ^{129}I, ^{90}Sr, ^{99}Tc, U, gamma scan, ICP metals, anions, volatile organics

(a) A = annually; M = monthly; Q = quarterly; Comp = composite.
(b) M Comp indicates river water was collected hourly and composited monthly for analysis.
(c) lo ^{3}H = low-level tritium analysis, which includes an electrolytic preconcentration.
(d) U = isotopic uranium.
(e) Q Cont = river water was sampled by continuous flow through a filter and resin column and composited monthly (M) or quarterly (Q) for analysis.
(f) Pu = isotopic plutonium.
(g) Numerous water quality analyses are performed by the U.S. Geological Survey (USGS) in conjunction with the National Stream Quality Accounting Network (NASQAN) Program. Thermograph stations are operated and maintained by the USGS.
(h) ICP = inductively coupled plasma analysis method.
(i) Three samples during irrigation season.

Table 4.2.2. Sediment Surveillance, 1996

Location[a]	Frequency	Analyses
River		
McNary Dam: Oregon shore 1/3 from Oregon shore 2/3 from Oregon shore Washington shore	A[b]	Gamma scan, ^{90}Sr, U,[c] Pu,[d] ICP[e] Metals
Priest Rapids Dam: Grant County shore 1/3 from Grant County shore 2/3 from Grant County shore Yakima County shore	A	Gamma scan, ^{90}Sr, U, Pu, ICP Metals
White Bluffs Slough	A	Gamma scan, ^{90}Sr, U, Pu, ICP Metals
100-F Slough	A	Gamma scan, ^{90}Sr, U, Pu, ICP Metals
Hanford Slough	A	Gamma scan, ^{90}Sr, U, Pu, ICP Metals
Richland	A	Gamma scan, ^{90}Sr, U, Pu, ICP Metals
Springs		
100-B Area Spring	A	Gamma scan, ^{90}Sr, U, ICP Metals
100-N Area Spring 8-13	A	Gamma scan, ^{90}Sr, U, ICP Metals
Hanford Spring 28-2	A	Gamma scan, ^{90}Sr, U, ICP Metals
300 Area Spring 42-2	A	Gamma scan, ^{90}Sr, U, ICP Metals
100-K Area Spring	A	Gamma scan, ^{90}Sr, U, ICP Metals
100-F Area Spring	A	Gamma scan, ^{90}Sr, U, ICP Metals

(a) See Figure 4.2.1.
(b) A = annually.
(c) U includes ^{235}U and ^{238}U analyzed by low-energy photon analysis.
(d) Pu = isotopic plutonium.
(e) ICP = inductively coupled plasma analysis method.

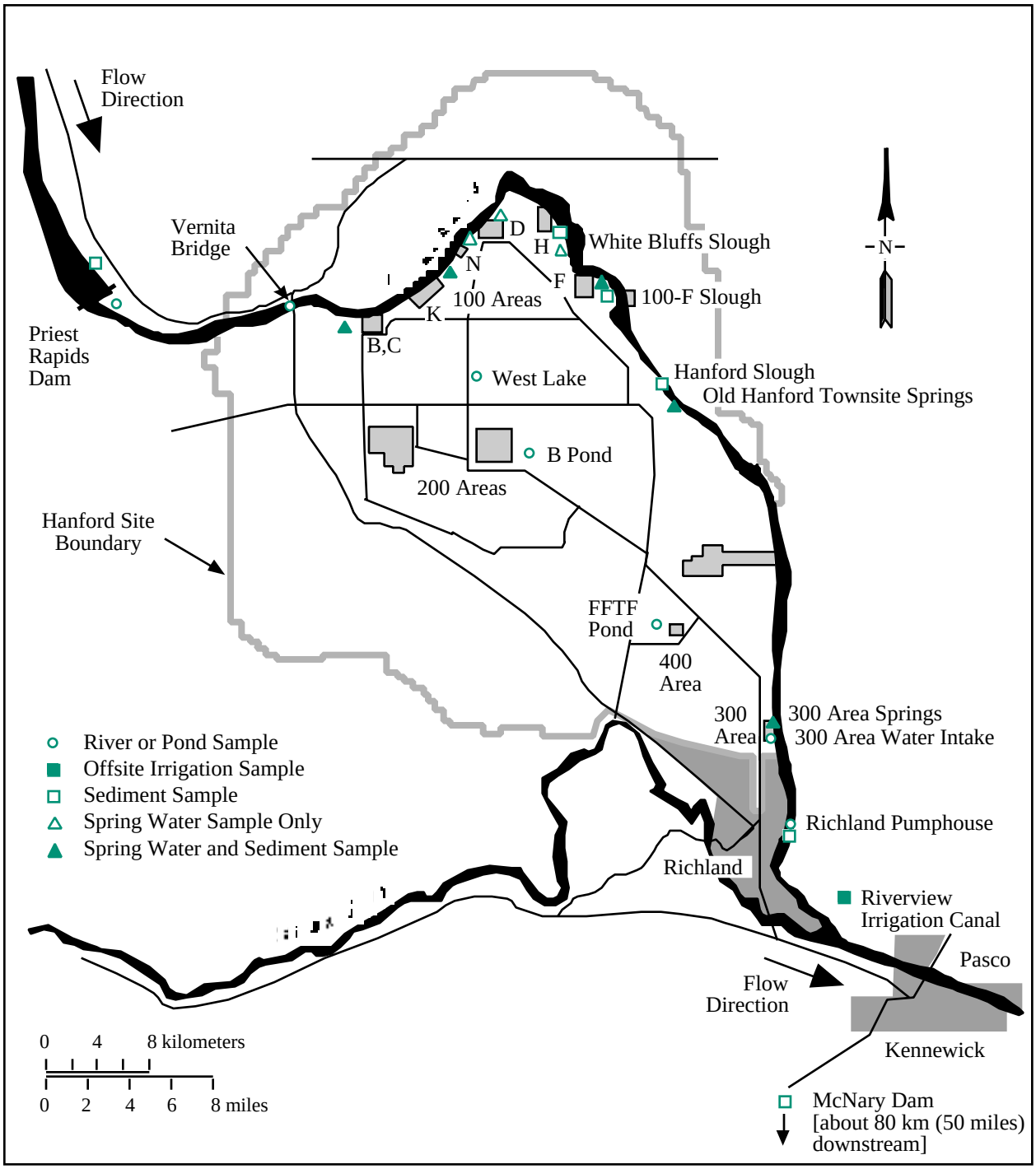

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Figure 4.2.1. Water and Sediment Sampling Locations, 1996

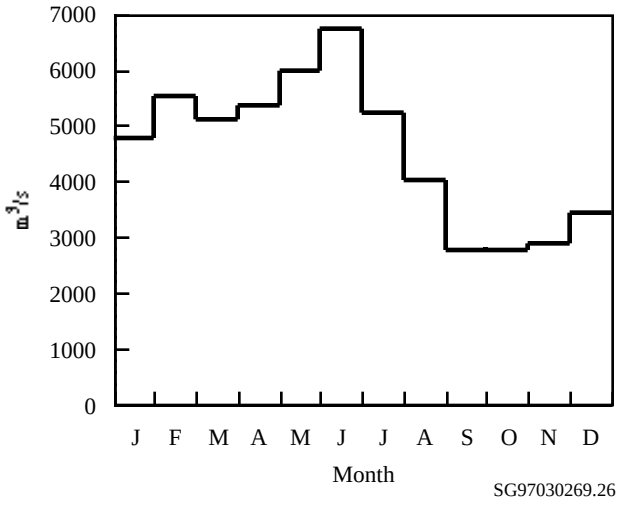

Figure 4.2.2. Mean Monthly Columbia River Flow Rates, 1996

discharges are identified and regulated for nonradiological constituents under the National Pollutant Discharge Elimination System in compliance with the Clean Water Act. The National Pollutant Discharge Elimination System-permitted discharges at Hanford are summarized in Section 2.2, "Compliance Status."

Washington State has classified the stretch of the Columbia River from Grand Coulee Dam to the Washington-Oregon border, which includes the Hanford Reach, as Class A, Excellent (WAC 173-201A). Water quality criteria and water use guidelines have been established in conjunction with this designation and are provided in Appendix C (Table C.1).

Collection of River Water Samples and Analytes of Interest

Samples of Columbia River water were collected throughout 1996 at the locations shown in Figure 4.2.1. Samples were collected from fixed-location monitoring stations at Priest Rapids Dam and the Richland Pumphouse and from Columbia River transects established near the Vernita Bridge, 100-F Area, 100-N Area, Old Hanford Townsite, 300 Area, and Richland Pumphouse. Samples were collected upstream from Hanford Site facilities at Priest Rapids Dam and Vernita Bridge to provide background data from locations unaffected by site operations. Samples were collected from all other locations to identify any increase in contaminant concentrations attributable to Hanford operations. The Richland Pumphouse is the first downstream point of river-water withdrawal for a municipal drinking water supply.

The fixed-location monitoring stations at Priest Rapids Dam and Richland Pumphouse consisted of both an automated sampler and a continuous flow system. Using the automated sampler, unfiltered samples of Columbia River water (cumulative samples) were collected hourly and composited monthly for radiological analyses (see Table 4.2.1). Using the continuous flow system, particulate and soluble fractions of select Columbia River water constituents were collected in a filter and resin column, respectively. Filter and resin samples were composited monthly or quarterly for radiological analyses. The river sampling locations and the methods used for sample collection are discussed in detail in DOE (1994a).

Analytes of interest in water samples collected from Priest Rapids Dam and Richland Pumphouse fixed-location monitoring stations included total alpha, total beta, selected gamma emitters, tritium, strontium-90, technetium-99, iodine-129, uranium-234, uranium-235, uranium-238, plutonium-238, and plutonium-239,240. Alpha and beta measurements provided a general indication of radioactive contamination. Gamma scans provided the ability to detect numerous specific radionuclides (see Appendix E). Sensitive radiochemical analyses and, in some cases, special sampling techniques were used to determine the concentrations of tritium, strontium-90, technetium-99, iodine-129, uranium-234, uranium-235, uranium-238, plutonium-238, and plutonium-239,240 in river water during the year. Radionuclides of interest were selected for analysis based on their presence in effluents discharged from site facilities or in near-shore groundwater underlying the Hanford Site and for their importance in determining water quality, verifying effluent control and effluent monitoring systems, and determining compliance with applicable standards. Analytical detection levels for all radionuclides were less than 10% of their respective ambient water quality criteria levels (see Appendix C, Table C.2).

Transect sampling was initiated as a result of findings of a special study conducted during 1987 and 1988 (Dirkes 1993). That study concluded that, under certain flow conditions, contaminants entering the river from Hanford are not completely mixed at routine monitoring stations. Incomplete mixing results in a slight conservative bias in the data generated using the routine single-point sampling systems at the 300 Area (Section 4.3, "Hanford Site Drinking Water Surveillance") and the Richland Pumphouse. The Vernita Bridge and Richland Pumphouse

transects were sampled quarterly during 1996. Annual transect sampling was conducted at the 100-F Area, 100-N Area, Old Hanford Townsite, and 300 Area sampling locations.

Columbia River transect water samples collected in 1996 were analyzed for both radiological and chemical contaminants (see Table 4.2.1). Metals, anions, and volatile organics, listed in DOE (1994d), were selected for analysis following reviews of existing surface-water and groundwater data, various remedial investigation/feasibility study work plans, and preliminary Hanford Site risk assessments (DOE 1992b, Evans et al. 1992, Dirkes et al. 1993, Blanton et al. 1995b, Napier et al. 1995). All radiological and chemical analyses of transect samples were performed on unfiltered water.

In addition to Columbia River monitoring conducted by Pacific Northwest National Laboratory in 1996, nonradiological water quality monitoring was also performed by the U.S. Geological Survey in conjunction with the National Stream Quality Accounting Network program. U.S. Geological Survey samples were collected along Columbia River transects quarterly at the Vernita Bridge and the Richland Pumphouse (see Appendix A, Table A.4). Sample analyses were performed at the U.S. Geological Survey laboratory in Denver, Colorado for numerous physical, biological, and chemical constituents.

Radiological Results for Columbia River Water Samples

Results of the radiological analyses of Columbia River water samples collected at Priest Rapids Dam and Richland Pumphouse during 1996 are reported by Bisping (1997) and summarized in Appendix A (Tables A.1 and A.2). These tables also list the maximum and mean concentrations of select radionuclides observed in Columbia River water in 1996 and during the previous 5 years. All radiological contaminant concentrations measured in Columbia River water in 1996 were less than DOE derived concentration guides (DOE Order 5400.5) and Washington State ambient surface-water quality criteria (WAC 173-201A and 246-290) levels (see Appendix C, Tables C.5 and C.2, respectively). Significant results are discussed and illustrated below, and comparisons to previous years are provided.

Concentrations of radionuclides monitored in Columbia River water were extremely low throughout the year. Radionuclides consistently detected in river water collected from monitoring stations during 1996 at concentrations greater than two times their total propagated analytical uncertainty included tritium, strontium-90, iodine-129, uranium-234, uranium-238, and plutonium-239,240. The concentrations of all other measured radionuclides were less than two times their respective total propagated analytical uncertainties, and so were essentially not detectable in over 75% of samples collected. Tritium, strontium-90, iodine-129, and plutonium-239,240 exist in worldwide fallout, as well as in effluents from Hanford facilities. Tritium and uranium occur naturally in the environment, in addition to being present in Hanford effluents.

Total alpha and total beta measurements are indicators of the general radiological quality of the river and provide an early indication of change. Figures 4.2.3 and 4.2.4 illustrate the average annual total alpha and total beta concentrations, respectively, at Priest Rapids Dam and Richland Pumphouse during the past 6 years. The 1996 average total alpha and total beta concentrations were similar to those observed during recent years. Monthly concentrations measured at the Richland Pumphouse in 1996 were not significantly different (paired sample comparison and two-tailed t-test, 5% significance level) from those measured at Priest Rapids Dam. The average concentrations in Columbia River water at Priest Rapids Dam and Richland Pumphouse in 1996 were less than 5% of their respective Washington State ambient surface-water quality criteria levels of 15 and 50 pCi/L (WAC 246-290).

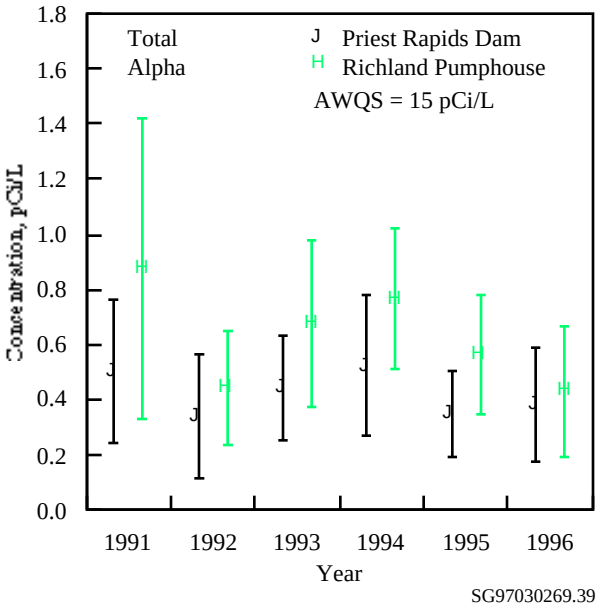

Figure 4.2.3. Annual Average Total Alpha Concentrations in Columbia River Water, 1991 Through 1996 (AWQS = ambient water quality standard)

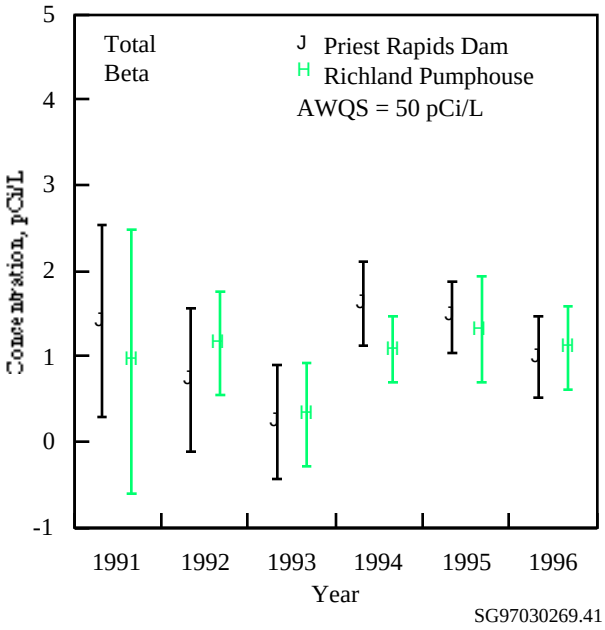

Figure 4.2.4. Annual Average Total Beta Concentrations in Columbia River Water, 1991 Through 1996 (AWQS = ambient water quality standard)

Figure 4.2.5 compares the average annual tritium concentrations at Priest Rapids Dam and Richland Pumphouse from 1991 through 1996. The general decline in tritium concentrations in river water remains evident at both locations. Statistical analysis (paired sample comparison, two-tailed t-test, 5% significance level) indicated that monthly tritium concentrations in river water at the Richland Pumphouse were significantly higher than those at Priest Rapids Dam. However, average tritium concentrations in Columbia River water collected from Priest Rapids Dam and Richland Pumphouse during 1996 were less than 1% of Washington State's ambient surface-water quality criteria level of 20,000 pCi/L (WAC 246-290). Onsite sources of tritium entering the river include groundwater seepage and direct discharge from outfalls located in the 100 Areas (see Section 3.1, "Facility Effluent Monitoring," and Section 4.8, "Groundwater Protection and Monitoring Program"). Tritium concentrations measured at the Richland Pumphouse, while representative of river water used by the city of Richland for drinking water, tend to overestimate the average concentrations of tritium in the river at this location (Dirkes 1993). This bias is attributable to the contaminated 200 Areas groundwater plume entering the river along the portion of shoreline extending from the Old Hanford Townsite to below the 300 Area, which is relatively close to the Richland Pumphouse sample intake. This plume is not completely mixed within the river at the Richland Pumphouse. Sampling along a transect at the pumphouse during 1996 confirmed the existence of a concentration gradient in the river under certain flow conditions and is discussed subsequently in this section. The extent to which samples taken from the Richland Pumphouse overestimate the average tritium concentrations in the Columbia River at this location is highly variable and appears to be related to the flow rate of the river just before and during sample collection.

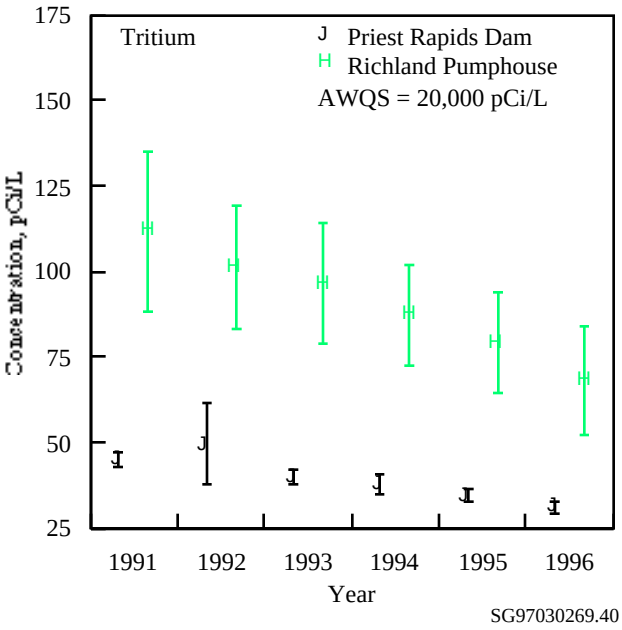

Figure 4.2.5. Annual Average Tritium Concentrations in Columbia River Water, 1991 Through 1996 (AWQS = ambient water quality standard)

The average annual strontium-90 concentrations in Columbia River water collected from Priest Rapids Dam and Richland Pumphouse from 1991 through 1996 are presented in Figure 4.2.6. Concentrations observed in 1996 were similar to those observed previously. Groundwater plumes containing strontium-90 enter the Columbia River throughout the 100 Areas (Dresel et al. 1995). The highest strontium-90 concentrations in groundwater onsite have been found in the 100-N Area as a result of past discharges to the 100-N Area liquid waste disposal facilities. Despite the Hanford source, the differences between monthly strontium-90 concentrations at Priest Rapids Dam and Richland Pumphouse in 1996 were not significant (paired sample comparison, two-tailed t-test, 5% significance level). Average strontium-90 concentrations in Columbia River water were approximately 1% of the 8-pCi/L ambient surface-water quality criteria level.

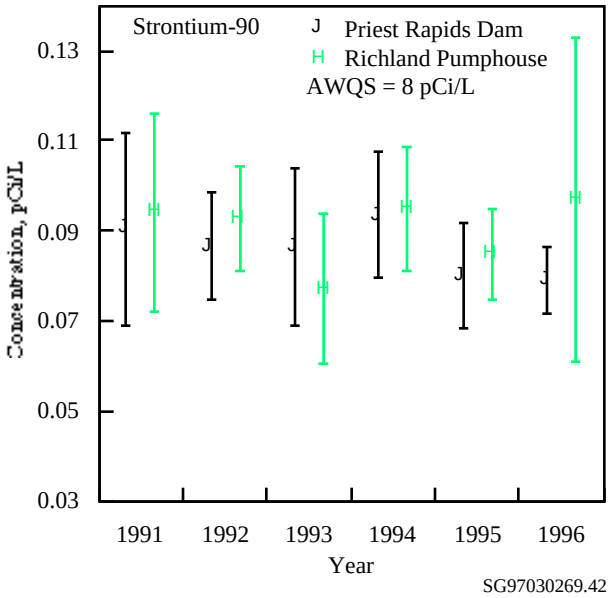

Figure 4.2.6. Annual Average Strontium-90 Concentrations in Columbia River Water, 1991 Through 1996 (AWQS = ambient water quality standard)

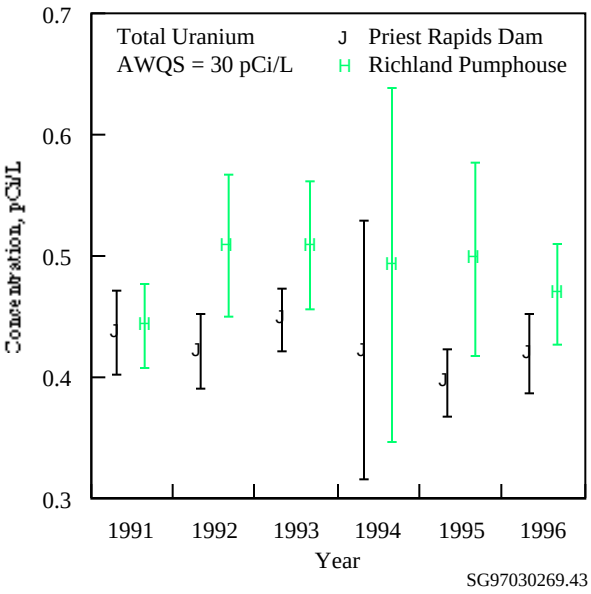

Figure 4.2.7. Annual Average Total Uranium Concentrations in Columbia River Water, 1991 Through 1996 (AWQS = ambient water quality standard)

Average annual total uranium concentrations (i.e., the sum of uranium-234, uranium-235, and uranium-238 concentrations) at Priest Rapids Dam and Richland Pumphouse for 1991 through 1996 are shown in Figure 4.2.7. The large error associated with 1994 results was attributed to an unusually low concentration found in the December sample of each location. Total uranium concentrations observed in 1996 were similar to those observed during recent years. Monthly total uranium concentrations measured at the Richland Pumphouse in 1996 were not significantly different from those measured at Priest Rapids Dam (paired sample comparison, two-tailed t-test, 5% significance level). Although there is no direct discharge of uranium to the river, uranium is present in the groundwater beneath the 300 Area as a result of past Hanford operations (see Section 4.8, "Groundwater Protection and Monitoring Program") and has been detected at elevated levels in riverbank springs in this area (see "Riverbank Springs Water" subsection). Naturally occurring uranium is also known to enter the river across from Hanford via irrigation return water and groundwater seepage associated with extensive irrigation north and east of the Columbia River (Dirkes 1990). There are currently no ambient surface-water quality criteria levels directly applicable to uranium. However, total uranium concentrations in the river during 1996 were well below the proposed EPA drinking water standard of 20 µg/L (30 pCi/L; EPA 1996).

The average annual iodine-129 concentrations for Priest Rapids Dam and Richland Pumphouse for 1991 through 1996 are presented in Figure 4.2.8. The large error observed at Priest Rapids Dam in 1994 is attributed to an unusually high third quarter result at that location. Only one quarterly iodine-129 result was available for the Richland Pumphouse during 1995 because of construction activities at the pumphouse. The average concentration of iodine-129 in Columbia River water was extremely low during 1996 (<0.1% of the Washington State ambient surface-water quality criteria [WAC 246-290] level of 1 pCi/L [1 million aCi/L]) and similar to levels observed during recent years. The onsite source of iodine-129 to the Columbia River is the discharge of contaminated groundwater along the portion of shoreline downstream of the Old Hanford Townsite (see Section 4.8, "Groundwater Protection and Monitoring Program"). The iodine-129 plume originated in the 200 Areas from past waste disposal practices. Quarterly iodine-129 concentrations in Columbia River water at the Richland Pumphouse were significantly higher than those at Priest Rapids Dam (paired sample comparison, two-tailed t-test, 5% significance level) (Dirkes and Hanf 1995).

During 1996, average plutonium-239,240 concentrations at Priest Rapids Dam and Richland Pumphouse were 42 ± 50 and 58 ± 47 aCi/L, respectively. No ambient surface-water quality criteria levels exist for

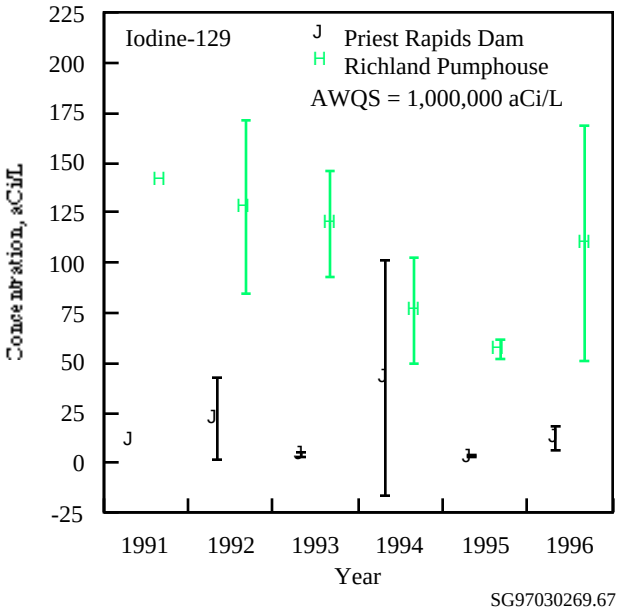

Figure 4.2.8. Annual Average Iodine-129 Concentrations in Columbia River Water, 1991 Through 1996 (AWQS = ambient water quality standard)

plutonium-239,-240; however, if the DOE derived concentration guides (DOE Order 5400.5; see Appendix C, Table C.5), which are based on a 100-mrem dose standard, are converted to a 4-mrem dose equivalent used to develop the drinking water standards and ambient surface-water quality criteria levels, 1.2 pCi/L (1.2 million aCi/L) would be the relevant guideline for plutonium-239,-240. As in previous years, there was no significant difference in concentrations at Priest Rapids Dam and Richland Pumphouse (paired sample comparison, t-test, 5% significance level) (Dirkes and Hanf 1995).

Radiological results of samples collected along Columbia River transects established at the Vernita Bridge, 100-F Area, 100-N Area, Old Hanford Townsite, 300 Area, and Richland Pumphouse during 1996 are presented in Appendix A (Table A.4) and Bisping (1997). Constituents that were consistently detected (in greater than 50% of river transect samples) at concentrations greater than two times their associated total propagated analytical uncertainty included tritium, strontium-90, uranium-234, and uranium-238. All measured concentrations of these radionuclides were less than applicable ambient surface-water quality criteria levels.

Tritium concentrations measured along Columbia River transects during September 1996 are depicted in Figure 4.2.9. The transects are displayed such that the observer's view is upstream. Vernita Bridge is the most upstream transect. Stations 1 and 10 are located along the Benton County and Franklin/Grant Counties shorelines, respectively. The highest mean tritium concentrations observed in 1996 river transect water (see Figure 4.2.9) were detected along the shoreline of the Old Hanford Townsite, where groundwater containing tritium concentrations in excess of the ambient surface-water quality criteria level of 20,000 pCi/L is known to discharge to the river (Dresel et al. 1995). Slightly elevated levels of tritium were also evident near the Hanford shoreline at the 100-N Area, 300 Area transect locations, and Richland Pumphouse shoreline. The presence of a tritium concentration gradient in the Columbia River at the Richland Pumphouse supports previous conclusions made by Backman (1962) and Dirkes (1993) that contaminants in the 200 Areas groundwater plume entering the river at, and upstream of, the 300 Area are not completely mixed at the Richland Pumphouse. The gradient is most pronounced during periods of relatively low flow. As noted since transect sampling was initiated in 1987, the mean concentration of tritium measured along the Richland Pumphouse transect was less than that measured in monthly composited samples from the pumphouse, illustrating the conservative bias of the fixed-location monitoring station.

Strontium-90 concentrations in 1996 transect samples were fairly uniform across the width of the river and varied little between transects (see Appendix A, Table A.3). The mean concentration of strontium-90 found during transect sampling at the Richland Pumphouse was similar to that measured in monthly composited samples from the pumphouse. The similarity indicates that strontium-90 concentrations in water collected from the fixed-location monitoring station are representative of the average strontium-90 concentration in the river at this location.

Total uranium concentrations (i.e., the sum of uranium-234, uranium-235, and uranium-238 concentrations) in 1996 were elevated along both the Benton and Franklin County shorelines of the 300 Area and Richland Pumphouse transects (see Appendix A, Table A.3). The highest total uranium concentration was measured near the Franklin County shoreline of the Richland Pumphouse transect and likely resulted from groundwater seepage and irrigation return canals on the east side of the river that contained naturally occurring uranium (Dirkes 1990). The mean concentration of total uranium across the Richland Pumphouse transect was similar to that measured in monthly composited samples from the pumphouse.

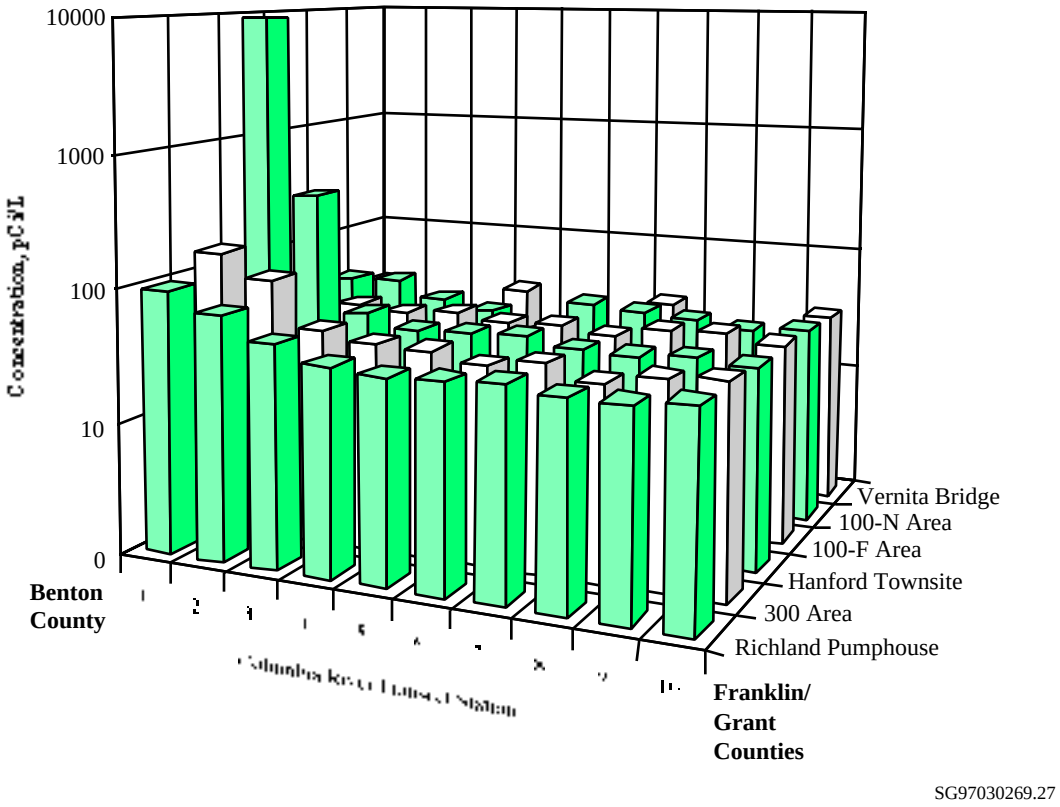

Figure 4.2.9. Mean Tritium Concentrations in Columbia River Transects, 1996

Nonradiological Results for Columbia River Water Samples

Nonradiological water quality data were compiled by the Pacific Northwest National Laboratory and the U.S. Geological Survey during 1996. A number of the parameters measured have no regulatory limits; however, they are useful as indicators of water quality and contaminants of Hanford origin. Potential sources of pollutants not associated with Hanford include irrigation return water and groundwater seepage associated with extensive irrigation north and east of the Columbia River (Dirkes 1990).

Figure 4.2.10 shows the preliminary Vernita Bridge and Richland Pumphouse U.S. Geological Survey results for 1991 through 1996 for several water quality parameters with respect to their applicable standards. The complete list of preliminary results obtained through the U.S. Geological Survey National Stream Quality Accounting Network program is documented in Bisping (1997) and is summarized in Appendix A (Table A.4). Final results are published annually by the U.S. Geological Survey (e.g., Wiggins et al. 1996). The 1996 U.S. Geological Survey results were comparable to those reported during the previous 5 years. Applicable standards for a Class A-designated surface-water body were met; however, the minimum detectable concentration of silver exceeded the Washington State acute toxicity standard. During 1996, there was no indication of any deterioration of water quality resulting from Hanford operations along the Hanford Reach of the Columbia River (see Appendix C, Table C.1).

Results of nonradiological sampling conducted by Pacific Northwest National Laboratory along transects of the Columbia River in 1996 at the Vernita Bridge, 100-F Area, 100-N Area, Old Hanford Townsite, 300 Area, and Richland Pumphouse are provided by Bisping (1997). The concentrations of volatile organics, metals, and anions observed in river water in 1996 were similar to those observed in the past. Acetone, trichloroethylene, chloroform, and toluene were occasionally detected and was found in Columbia River transect samples. All volatile organic compound concentrations were less than EPA ambient surface-water quality criteria levels (see Appendix C, Table C.3).

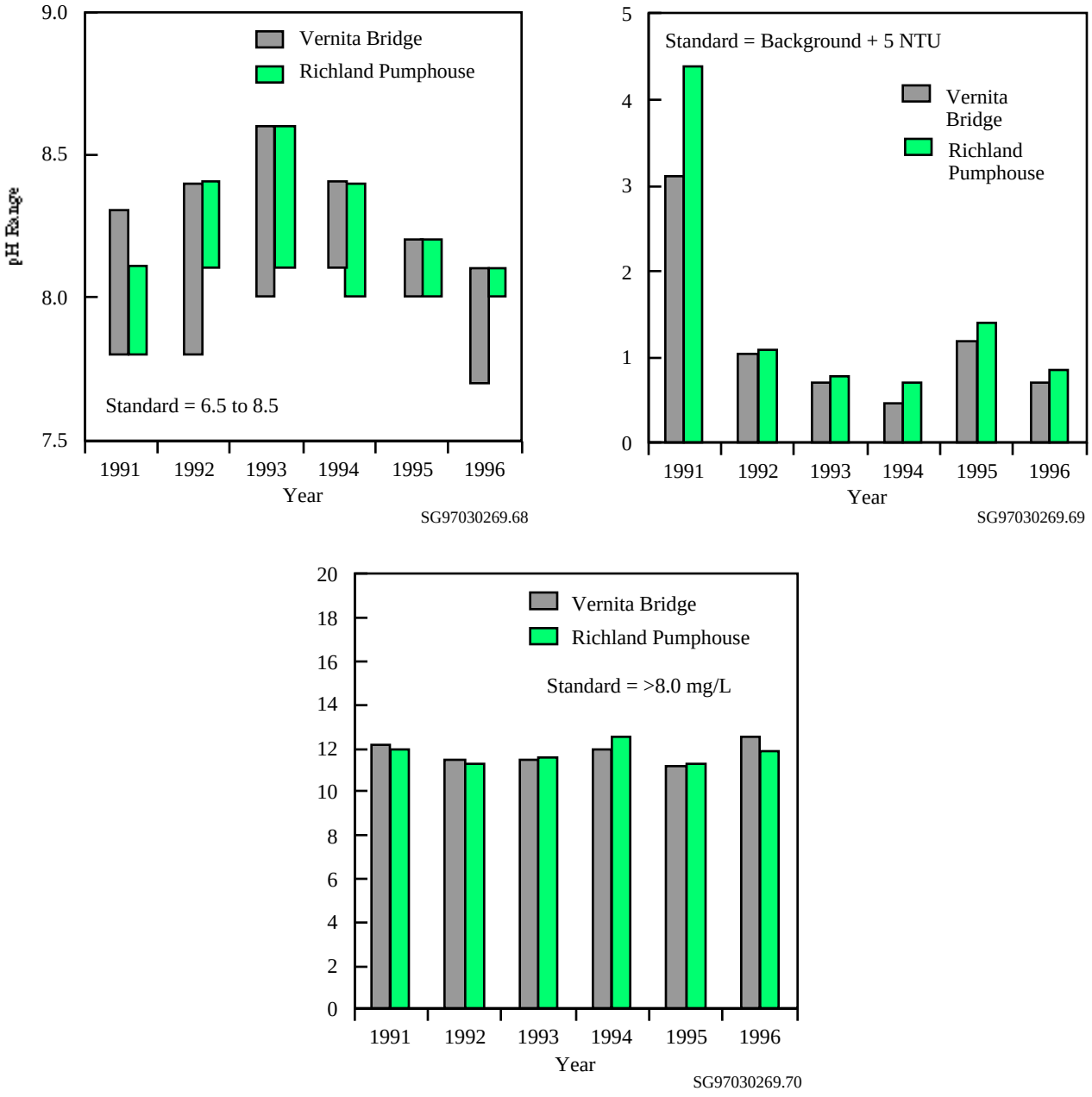

Figure 4.2.10. Preliminary U.S. Geological Survey Columbia River Water Quality Measurements, 1991 Through 1996

Several metals and anions were detected in Columbia River transect samples both upstream and downstream of the Hanford Site at levels comparable to those reported by the U.S. Geological Survey as part of their ongoing National Stream Quality Accounting Network program. Aluminum and iron were detected at both Vernita Bridge and Richland Pumphouse, with somewhat higher concentrations of both at the Richland Pumphouse. Arsenic, antimony, beryllium, cadmium, chromium, cobalt, lead, magnesium, manganese, nickel, selenium, silver, strontium, thallium, tin, vanadium, and zinc were only occasionally detected, with similar levels at most locations. Trace levels of mercury (below 0.000001 µg/L) were detected in September 1996 transect samples at Vernita Bridge, 100-F Area, and Richland Pumphouse. Nitrate concentrations were elevated along the Franklin County shoreline of the Old Hanford Townsite, 300 Area, and Richland Pumphouse transects and likely resulted from groundwater seepage associated with extensive irrigation north and east of the Columbia River. Groundwater nitrate contamination associated with high fertilizer and water usage in Franklin County has been documented by the U.S. Geological Survey (1995). Numerous wells in western Franklin County exceed the EPA maximum contaminant level for nitrate. With the exception of nitrate, aluminum, and iron, which had the highest average quarterly concentrations at the Richland Pumphouse, no consistent differences were found between average quarterly contaminant concentrations in the Vernita Bridge and Richland Pumphouse transect samples.

Washington State ambient surface-water quality criteria for cadmium, copper, lead, nickel, silver, and zinc are total-hardness dependent (WAC 246-290; see Appendix C, Table C.3). Criteria for Columbia River water were calculated using a total hardness of 55 mg/L as $CaCO_3$ (calcium carbonate), the limiting value based on U.S. Geological Survey monitoring of Columbia River water near Vernita Bridge and Richland Pumphouse over the past 6 years. The total hardness reported by the U.S. Geological Survey at those locations from 1991 through 1996 ranged from 55 to 77 mg/L as $CaCO_3$. All metal and anion concentrations in river water were less than the Washington State ambient surface-water quality criteria levels for acute toxicity, except for silver and cadmium that exceeded the criteria in a few samples. The chronic toxicity levels for lead and selenium were occasionally exceeded in Columbia River transect samples. All mercury concentrations were below the Washington State chronic toxicity level (WAC 246-290). The chronic toxicity criteria are based on a 4-day average concentration not to be exceeded more than once every 3 years. Transect samples are grab samples; therefore, they are not directly comparable to the standard. Antimony, arsenic, and thallium concentrations occasionally exceeded EPA standards to protect human health for the consumption of water and organisms. However, similar concentrations were found at Vernita Bridge and Richland Pumphouse (see Appendix C, Table C.3). Silver has not been identified as a contaminant of concern from the Hanford Site to the Columbia River (Blanton et al. 1995b, Napier et al. 1995).

Columbia River Sediments

Sediments in the Columbia River contain low concentrations of radionuclides and metals of Hanford origin as well as radionuclides from nuclear weapons testing fallout (Robertson and Fix 1977, Beasley et al. 1981, Woodruff et al. 1992, Blanton et al. 1995b). Public exposures are well below the level at which routine surveillance of Columbia River sediments is required (Sula 1980, Wells 1994). However, periodic sampling is necessary to confirm the low levels and to ensure that no significant changes have occurred for this pathway. The accumulation of radioactive materials in sediment can lead to human exposure through ingestion of aquatic species, through sediment resuspension into drinking water supplies, or as an external radiation source irradiating people who are fishing, wading, sunbathing, or participating in other recreational activities associated with the river or shoreline (DOE 1991).

As a result of past operations at the Hanford Site, large quantities of radioactive and nonradioactive materials were discharged to the Columbia River. On release to the river, the materials were dispersed rapidly, sorbed onto detritus and inorganic particles, incorporated into aquatic biota, and deposited on the riverbed as sediment. Fluctuations in the river flow rate, as a result of the operation of hydroelectric dams, annual spring freshets, and occasional floods, have resulted in the resuspension, relocation, and subsequent redeposition of the contaminated sediments (DOE 1994a).

Since the shutdown of the original single-pass reactors, the contaminant burden in the surface sediments has been decreasing as a result of radioactive decay and the subsequent deposition of uncontaminated material. However, discharges of some pollutants from the Hanford Site to the Columbia River still occur via direct liquid effluent discharges from Hanford facilities (see Section 3.1, "Facility Effluent Monitoring") and via contaminated groundwater seepage (McCormack and Carlile 1984, Dirkes 1990, DOE 1992c, Peterson 1992).

A special study was conducted in 1994 to investigate the difference in sediment grain-size composition and total organic carbon content at routine monitoring sites (Blanton et al. 1995b). Physicochemical sediment characteristics were found to be highly variable among monitoring sites along the Columbia River. Samples containing the highest percentage of silts, clays, and total organic carbon were collected above McNary Dam and from White Bluffs Slough. All other samples primarily consisted of sand. Higher contaminant burdens were generally associated with sediments containing higher total organic carbon and finer grain-size distributions, which is consistent with other sediment investigations (Nelson et al. 1966, Lambert 1967, Richardson and Epstein 1971, Gibbs 1973, Karickhoff et al. 1978, Suzuki et al. 1979, Sinex and Helz 1981, Tada and Suzuki 1982, Mudroch 1983).

Collection of Sediment Samples and Analytes of Interest

During 1996, samples of Columbia River surface sediments (0 to 15-cm [0 to 6-in.] depth) were collected from 6 river locations that are permanently submerged and 5 riverbank spring locations that are periodically inundated (see Figure 4.2.1 and Table 4.2.2). Samples were collected above Priest Rapids Dam (the nearest upstream impoundment) upstream of Hanford facilities to provide background data from an area unaffected by site operations. Samples were collected downstream of Hanford above McNary Dam (the nearest downstream impoundment) to identify any increase in contaminant concentrations. Note that any increases in contaminant concentrations found in sediment above McNary Dam relative to that found above Priest Rapids Dam do not necessarily reflect a Hanford source. The confluences of the Columbia River with the Yakima, Snake, and Walla Walla Rivers lie between the Hanford Site and McNary Dam. Several towns and factories in these drainages may also contribute to the contaminant load found in McNary Dam sediment. Sediment samples were also collected along the Hanford Reach of the Columbia River from areas close to contaminant discharges (e.g., riverbank springs), from slackwater areas where fine-grained material is known to deposit (e.g., the White Bluffs, 100-F Area, and Hanford sloughs), and from an area commonly used by the public (e.g., the Richland shoreline).

Monitoring sites located at McNary and Priest Rapids Dams consisted of four stations spaced equidistant on a transect line crossing the Columbia River. All other monitoring sites consisted of a single sampling location. Samples of permanently inundated river sediment, herein referred to as river sediment, were collected using a grab sampler with a 235-cm^2 opening. Samples of periodically inundated river sediment, herein referred to as riverbank spring sediment, were collected using a large plastic spoon, immediately following the collection of riverbank springwater samples. Sampling methods are discussed in detail in DOE (1994a). All sediment samples were analyzed for gamma emitters (see Appendix E), strontium-90, uranium-235, uranium-238, and inductively coupled plasma (method) metals (DOE 1994a). River sediment samples were also analyzed for plutonium-238, plutonium-239,240, and lead. Sample analyses of Columbia River sediments were selected based on findings of previous Columbia River sediment investigations, reviews of past and present effluents discharged from site facilities, and reviews of contaminant concentrations observed in near-shore groundwater monitoring wells.

Radiological Results for River Sediment Samples

Results of the radiological analyses on river sediment samples collected during 1996 are reported by Bisping (1997) and summarized in Appendix A (Table A.5). Radionuclides consistently detected in river sediment adjacent and downstream of Hanford during 1996 at concentrations greater than two times their total propagated analytical uncertainty included cobalt-60, strontium-90, cesium-137, europium-155, uranium-238, plutonium-238, and plutonium-239,240. The concentrations of all other measured radionuclides were less than two times their respective total propagated analytical uncertainties in over 50% of samples collected. Strontium-90 and plutonium-239,240 exist in worldwide fallout, as well as in effluents from Hanford facilities. Uranium occurs naturally in the environment in addition to being present in Hanford effluents. Comparisons of contaminant concentrations between sediment sampling locations are made below. Because of variations in the bioavailability of contaminants in various sediments, no state or federal freshwater sediment criteria are available to assess the sediment quality of the Columbia River (EPA 1994).

Radionuclide concentrations reported in river sediment in 1996 were similar to those reported for previous years (see Appendix A, Table A.5). No appreciable differences in isotopic uranium concentrations were noted between locations. Minimum, median, and maximum concentrations of select radionuclides measured in river sediment from 1991 through 1996 are presented in Figure 4.2.11. Sampling areas include stations at Priest Rapids and

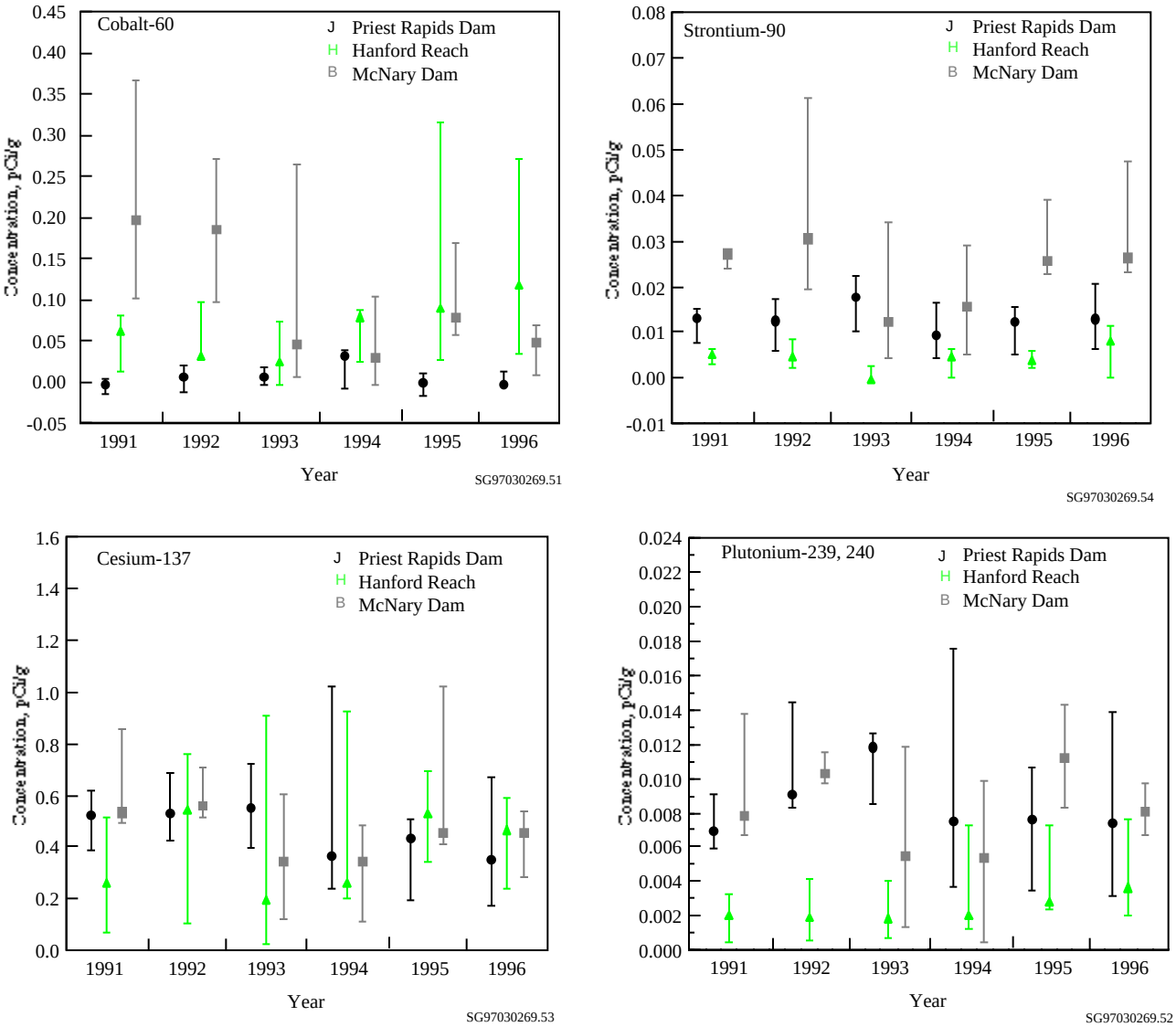

Figure 4.2.11. Minimum, Median, and Maximum Concentrations of Select Radionuclides Measured in Columbia River Sediments, 1991 Through 1996

McNary Dams as well as the Hanford Reach stations: White Bluffs, 100-F Area, Hanford sloughs, and Richland Pumphouse. Strontium-90 is the only radionuclide to exhibit consistently higher median concentrations at McNary Dam from 1991 through 1996. The rank of all other radionuclide concentrations by sampling area varied from year to year. The median concentrations of strontium-90 and plutonium-239,240 were highest in McNary Dam sediment in 1996. The median concentration of cobalt-60 was highest along the Hanford Reach. No other radionuclides measured in 1996 exhibited appreciable differences in concentrations between locations.

Radiological Results for Riverbank Spring Sediment Samples

Riverbank spring sediment sampling was initiated in 1993 at the Old Hanford Townsite and 300 Area. The riverbank springs in the 100-B, 100-F, 100-K, and 100-N Areas were added in 1995. Sediments at all other riverbank spring sampling locations consisted of predominantly large cobble and were unsuitable for sample collection. Sediment samples were not collected in 1996 at the 100-K Area because of low spring-water flow and specific conductances similar to the Columbia River,

which indicates bank storage of river water. Sediment samples were not collected in 1996 at the 100-N Area because of large cobble at the spring location.

Radiological results for riverbank spring sediment collected in 1996 are presented in Bisping (1997) and are summarized in Appendix A (Table A.5). Results were similar to those observed for previous years, with the exception of total uranium in 300 Area spring sediment that did not show the elevated concentrations reported in 1995. Radionuclide concentrations in riverbank spring sediment were similar to those observed in river sediment in 1996.

Nonradiological Results for Columbia River Sediment Samples

Metal concentrations observed in Columbia River sediment in 1996 are reported by Bisping (1997) and are summarized in Appendix A (Table A.6). Detectable amounts of most metals were found in all Columbia River sediment samples, with the exception of silver. Concentrations of silver were below the detection limit (0.52 mg/kg) for all samples. Overall median concentrations of most metals were similar for most samples, with McNary Dam sediments having slightly higher median concentrations of some metals (Figure 4.2.12). The maximum and highest median concentrations of chromium were found in riverbank spring sediment.

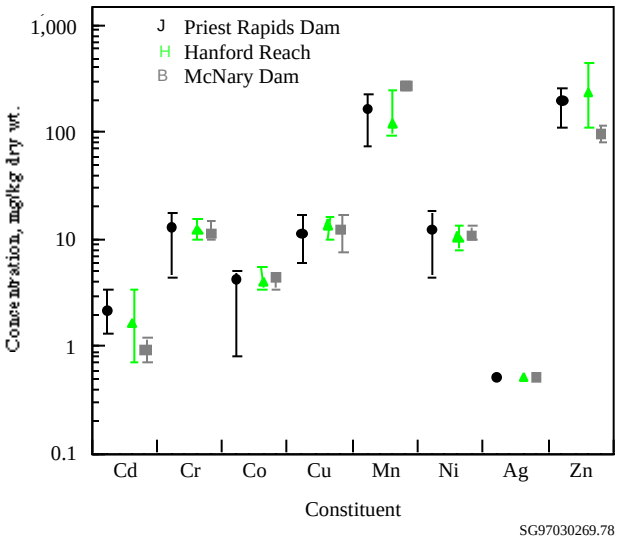

Figure 4.2.12. Minimum, Median, and Maximum Concentrations of Select Metals Measured in Columbia River Sediments, 1996

Riverbank Springs Water

The Columbia River is the primary discharge area for the unconfined aquifer underlying the Hanford Site (Dresel et al. 1995). Groundwater provides a means for transporting Hanford-associated contaminants, which have leached into groundwater from past waste disposal practices, to the Columbia River (McCormack and Carlile 1984, Dirkes 1990, DOE 1992a, Peterson 1992). Contaminated groundwater enters the Columbia River via surface and subsurface discharge. Discharge zones located above the water level of the river are identified in this report as riverbank springs. Routine monitoring of riverbank springs offers the opportunity to characterize the quality of groundwater being discharged to the river and to assess the potential human and ecological risk associated with the spring water.

The seepage of groundwater into the Columbia River has occurred for many years. Riverbank springs were documented along the Hanford Reach long before Hanford operations began during World War II (Jenkins 1922). McCormack and Carlile (1984) walked the 66-km (41-mi) stretch of Benton County shoreline of the Hanford Reach of the Columbia River in 1983 and identified 115 springs. They reported that the predominant areas of groundwater discharge at that time were in the vicinity of the 100-N Area, Old Hanford Townsite, and 300 Area. The predominance of the 100-N Area may no longer be valid because of declining water-table elevations in response to the decrease in liquid waste discharges from Hanford operations to the ground. In recent years, it has become increasingly difficult to locate springs in the 100-N Area.

The presence of springs also varies with river stage. Dresel et al. (1995) reported that groundwater levels in the 100 and 300 Areas are heavily influenced by river-stage fluctuations. Water levels in the Columbia River fluctuate greatly on annual and even daily cycles and are controlled by the operation of Priest Rapids Dam upstream of the site. Water flows into the aquifer (as bank storage) as the river stage rises and flows in the opposite direction as the river stage falls. Following an extended period of low river discharge, groundwater discharge zones located above the water level of the river may cease to exist once the level of the groundwater comes into equilibrium with the level of the river. Thus, springs are most readily identified immediately following a decline in river stage. Bank storage of river water also affects the contaminant concentration of the springs. Spring-water discharge immediately following a river stage decline generally consists

of river water or a river-groundwater mix. The percent contribution of groundwater to spring-water discharge is believed to increase over time following a drop in river stage.

Because of the effect of bank storage on groundwater discharge and contaminant concentration, it is difficult to estimate the volume of contaminated groundwater discharged to the Columbia River within the Hanford Reach. The estimated total groundwater discharge from the upstream end of the 100 Areas to south of the 300 Area is approximately 66,500 m^3/day (2,350,000 ft^3/day).[(a)] This amount is 0.02% of the long-term average flow rate of the Columbia River, which illustrates the tremendous dilution potential offered by the river. Note that not all of the groundwater discharged to the river contains contaminants originating from Hanford Site operations. Riverbank spring studies conducted in 1983 (McCormack and Carlile 1984) and in 1988 (Dirkes 1990) noted that spring discharges had a localized effect on river contaminant concentrations. Both studies reported that the volume of groundwater entering the river at these locations was very small relative to the flow of the river and that the impact of groundwater discharges to the river was minimal.

Riverbank Springs Water Samples and Analytes of Interest

Routine monitoring of select riverbank springs was initiated in 1988 at the 100-N Area, Old Hanford Townsite, and 300 Area. Monitoring was expanded in 1993 to include the 100-B, 100-D, 100-H, and 100-K Areas. The 100-F Area spring was added in 1994. The locations of all riverbank springs sampled in 1996 were identified in Figure 4.2.1. Sample collection methods are described in DOE (1994a). Analytes of interest for samples from riverbank springs were selected based on findings of previous investigations, reviews of contaminant concentrations observed in nearby groundwater monitoring wells, and results of preliminary risk assessments. Sampling is conducted annually during low river flow, typically August through September.

For 1996, high Columbia River flows delayed sample collection until November. Samples were not collected at the 100-K Area because of low riverbank spring flows and specific conductances similar to the Columbia River (i.e., bank storage was apparent). The 100-H Area spring was under water during all sampling attempts in 1996. Samples from riverbank springs collected during 1996 were analyzed for gamma-emitting radionuclides, total alpha, total beta, and tritium. Samples from selected springs were analyzed for strontium-90, technetium-99, uranium-234, uranium-235, and uranium-238. Iodine-129 analysis was included for locations where iodine-129 was known to exist in the groundwater as a result of past Hanford operations. Samples were also analyzed for various nonradiological contaminants, including metals, anions, and volatile organic compounds. All analyses were conducted on unfiltered samples.

Results for Riverbank Springs Water

Hanford-origin contaminants continued to be detected in riverbank spring water entering the Columbia River along the Hanford Site during 1996. The locations and extent of contaminated discharges were consistent with recent groundwater surveys. Tritium, strontium-90, technetium-99, uranium-234, uranium-235, uranium-238, metals (aluminum, arsenic, barium, beryllium, calcium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, selenium, sodium, strontium, and zinc), volatile organics (chloroform [100-D and 100-N Areas], tetrahydrofuran and trichloroethylene [100-B Area], and anions (bromide, chloride, fluoride, nitrate, and sulfate) were detected in spring water along the 100 Areas shoreline. Tritium, technetium-99, iodine-129, uranium-234, uranium-235, uranium-238, metals (aluminum, arsenic, barium, beryllium, calcium, cobalt, chromium, copper, iron, lead, magnesium, manganese, potassium, selenium, sodium, strontium, vanadium, and zinc), and anions (bromide, chloride, fluoride, nitrate, and sulfate) were detected in spring water along the portion of shoreline extending from the Old Hanford Townsite to below the 300 Area. The contaminant concentrations in spring water are typically lower than those found in near-shore groundwater wells because of bank storage effects.

The results of radiological and chemical analyses conducted on riverbank spring samples in 1996 are documented by Bisping (1997). Radiological results obtained in 1996 are summarized in Appendix A (Table A.7) and compared to those reported in 1991 through 1995. In the following discussion, radiological and nonradiological results are addressed separately. Contaminant concentration trends are illustrated for locations for which more than 3 years of data are available.

(a) Stuart Luttrell, Pacific Northwest National Laboratory, Richland, Washington, January 1995.

Radiological Results for Riverbank Springs Water Samples

All radiological contaminant concentrations measured in riverbank springs in 1996 were less than the DOE derived concentration guides (DOE Order 5400.5, see Appendix C, Table C.5). However, tritium concentrations in the 100-B Area and along the Old Hanford Townsite exceeded the Washington State ambient surface-water quality criteria levels (WAC 246-290, see Appendix C, Table C.1) and were close to these criteria levels at the 100-N Area. There are no ambient surface-water quality criteria levels directly applicable to uranium. However, total uranium concentrations (i.e., the sum of uranium-234, uranium-235, and uranium-238) exceeded the site-specific proposed EPA drinking water standard in the 300 Area (Appendix C, Table C.2) and were close to these levels for the 100-F Area. Total alpha concentrations were elevated at the 100-F and 300 Areas. Total beta concentrations were elevated at the 100-F Area. All other radionuclide concentrations were less than ambient surface-water quality criteria levels. The range of concentrations of select radionuclides measured in riverbank spring water from 1991 through 1996 is presented in Table 4.2.3.

Tritium concentrations varied widely with location. The highest concentrations were detected in the Old Hanford Townsite riverbank spring (41,000 ± 3,100 pCi/L), followed by the 100-B Area (24,000 ± 1,800 pCi/L), 100-N Area (17,000 ± 1,300 pCi/L), and 300 Area springs (3,400 ± 360 pCi/L). The Washington State ambient surface-water criteria for tritium is 20,000 pCi/L (WAC 246-290). Tritium concentrations in spring water from the 100-F Area (1,800 ± 240 pCi/L) and 100-D Area (1,000 ± 200 pCi/L) were also elevated compared to the 1996 average Columbia River concentrations at Priest Rapids Dam (31 pCi/L).

Samples from springs in the 100-B, 100-N, Old Hanford Townsite, and 300 Areas were analyzed for technetium-99 in 1996. Historically, the highest concentrations are normally found in the 100-H Area; however, this spring was under water during all 1996 sampling attempts and no sample was obtained. The highest technetium-99 concentration was found in water from the Old Hanford Townsite spring (38 ± 4.5 pCi/L).

Uranium was found in all riverbank spring samples in 1996, and the highest concentration was found for the 300 Area spring (34 ± 2.5 pCi/L) downgradient from the retired process trenches.

Iodine-129 was detected in the Old Hanford Townsite and 300 Area riverbank springs; the highest concentration was found for the Old Hanford Townsite spring (0.086 ± 0.010 pCi/L). This value was elevated compared to the 1996 average concentration measured at Priest Rapids Dam (0.000013 ± 0.0000058 pCi/L) but was well below the surface-water criteria of 1 pCi/L (see Appendix C, Table C.2).

Strontium-90 was analyzed for in samples from the 100-B, 100-D, 100-F, and 100-N Areas for 1996. The highest concentrations were found in the 100-D Area (1.8 ± 0.34 pCi/L). Beta activity paralleled that of strontium-90. Results are consistent with those found in previous years. Before 1993, however, the highest levels of strontium-90 and total beta were found in the 100-N Area (Table 4.2.4). These high concentrations were measured in samples collected from near-shore groundwater wells and not from riverbank springs.

The Near-Facility Environmental Monitoring Program has historically sampled the 100-N Area riverbank seepage from either the 199-N-8T monitoring well, which is located close to the river, or the 199-N-46 monitoring well (caisson), which is slightly inland from well 199-N-8T (see Figure 3.2.4). Well 199-N-8T was also sampled by Pacific Northwest National Laboratory in 1991. In 1992, the Pacific Northwest National Laboratory sample was collected from well 199-N-46. In 1993, 1994, and 1995, Pacific Northwest National Laboratory 100-N Area spring samples were collected from actual groundwater seepage entering the river along the shoreline. Sampling in this manner is consistent with the sampling protocol at other riverbank spring locations and avoids duplicating efforts of the Near-Facility Environmental Monitoring Program.

For 1993 to 1996, there was no visible shoreline seepage present directly adjacent to well 199-N-8T or well 199-N-46 during the sampling period. The 100-N Area spring samples were instead collected from the nearest visible downstream riverbank spring. As a result of the relative proximity of the riverbank springs and monitoring wells to the contaminant plumes emanating from the 100-N Area and as a result of bank-storage effects, some contaminant concentrations measured in the spring water were distinctly different from those previously measured in either of the two wells (see Table 4.2.4). The concentrations of strontium-90 and total beta were much lower in 100-N Area riverbank spring water than in near-shore groundwater. Tritium concentrations in riverbank spring water were similar to

Table 4.2.3. Range of Radiological Data for Columbia Riverbank Springs, 1991 Through 1996

Location	No. of Samples	Concentration, pCi/L Total Alpha	Total Beta	Iodine-129	Strontium-90	Technetium-99	Tritium	Total Uranium
100-B Spring	6	1.1 - 3.5	7.7 - 38	NS[a]	-0.11 - 0.0	8.4 - 25	11,000 - 24,000	1.6 - 3.2
100-K Spring[b]	2	0.61 - 1.6	1.8 - 3.6	NS	-0.031 - 0.1	-0.021 - 0.8	18,000 - 20,000	1.3 - 2.3
100-N Spring 8-13	7	0.043 - 8.9	1.5 - 24,000	NS	-0.01 - 1,100	0.84 - 2.4	4,900 - 31,000	0.24 - 2.5
100-D Spring	6	0.27 - 2.9	2.1 - 21	NS	0.069 - 9.4	-0.24 - 0.07	87 - 13,000	0.28 - 1.9
100-H Spring	4	3.3 - 4.6	39 - 69	NS	12 - 25	44 - 140	690 - 1,200	5.2 - 8.4
100-F Spring	3	2.6 - 41	1.7 - 65	NS	-0.03 - 0.09	-0.03 - 0.0	620 - 1,800	3.4 - 9.2
Hanford Spring 28-2	8	0.82 - 4.9[c]	4.8 - 95	0.044 - 0.22	-5.4 - 0.12	2 - 130	6,300 - 170,000	1.6 - 4.3[d]
300 Area Spring 42-2	8	13 - 110[e]	3.3 - 29	0.0019 - 0.0049	0.014 - 0.2	0.5 - 14[f]	1,300 - 12,000	24 - 130
Ambient Surface-Water Quality Criteria Level		15[g,h]	50[g]	1[i]	8[g]	900[i]	20,000[g]	20[i]

(a) No sample.
(b) Not sampled in 1996.
(c) 5 samples analyzed.
(d) 6 samples analyzed.
(e) 3 samples analyzed.
(f) 7 samples analyzed.
(g) WAC 246-290 and 40 CFR 141.
(h) Ambient surface-water quality criteria level for total alpha excludes uranium.
(i) Proposed standard (EPA 1996).

Table 4.2.4. Select Radionuclide Concentrations in 100-N Riverbank Spring Water, 1991 Through 1996

Year	Concentration, pCi/L[a]		
	^{3}H	Total beta	^{90}Sr
1991[b]	11,300 ± 1,040	7,140 ± 574	5,110 ± 1,000
1992[c]	4,870 ± 501	24,100 ± 1,730	10,900 ± 2,020
1993[d]			
Min	28,500 ± 2,220	2.41 ± 3.17	-0.0104 ± 0.221
Max	28,900 ± 2,260	4.50 ± 3.32	0.0204 ± 0.256
1994[d]	30,900 ± 2,380	8.79 ± 2.26	0.129 ± 0.107
1995[d]	12,000 ± 969	1.48 ± 1.49	0.079 ± 0.104
1996[d]	17,100 ± 1,340	4.48 ± 1.81	0.0527 ± 0.0479

(a) Concentrations are ±2 total propagated analytical uncertainty.
(b) Samples collected from well 199-N-8T (see Figure 3.2.5).
(c) Sample collected from well 199-N-46 (see Figure 3.2.5).
(d) Sample collected from shoreline spring downstream of well 199-N-8T.

those found in well 199-N-46 (see Table 3.2.5). Tritium and strontium-90 were the only contaminants with measured concentrations greater than two times their total propagated analytical uncertainty at the 100-N Area spring in 1996. Tritium and strontium-90 concentrations were 86% and 0.66% of their ambient surface-water quality criteria levels, respectively (see Appendix C, Table C.3).

Concentrations of select radionuclides in riverbank spring water near the Old Hanford Townsite from 1991 through 1996 are provided in Figure 4.2.13. Total beta and technetium-99 concentrations in 1996 were similar to those observed in 1994 and 1995 and slightly lower than those observed prior to 1994. The 1996 tritium concentration was similar to 1994 and 1995 results but well below values reported from 1991 through 1993. Annual fluctuations in these tritium concentrations may reflect the influence of bank storage during the sampling period. Technetium-99 and total uranium concentrations were also detected in Old Hanford Townsite spring water in 1996 at 4.2% and 12% of their respective ambient surface-water quality criteria levels and the proposed EPA drinking water standard for uranium (see Appendix C, Table C.3). The iodine-129 concentration measured in the Old Hanford Townsite riverbank spring water for 1996 was 8.6% of the ambient surface-water quality standard (see Appendix C, Table C.3).

Figure 4.2.14 depicts the concentrations of select radionuclides in the 300 Area riverbank spring from 1991 through 1996. Results in 1996 were similar to those observed previously, except that tritium concentrations were lower in 1996. Elevated contaminant concentrations during 1992 are believed to have resulted from coordinated efforts with Priest Rapids Dam to control the water level of the river during the 1992 riverbank spring sampling activities. Maintaining a low river-water level during sampling in 1992 maximized the contribution of groundwater in the springs and minimized the bank-storage effect. The elevated tritium concentrations measured in the 300 Area riverbank spring are indicators of the contaminated groundwater plume emanating from the 200 Areas (Dresel et al. 1995). Technetium-99 and iodine-129 are also contained in the 200 Areas contaminated groundwater plume. Tritium, technetium-99, and iodine-129 concentrations in 300 Area riverbank spring water in 1996 were 17%, 0.14%, and 0.22% of their respective ambient surface-water quality criteria levels (see Appendix C, Table C.3). The highest total uranium concentrations in riverbank spring water from 1991 through 1996 were found in the 300 Area riverbank springs, with the 1996 concentration 250% times higher than the proposed site-specific EPA drinking water standard (13.4 pCi/L; see Appendix C, Table C.2). Elevated uranium concentrations exist in the unconfined aquifer beneath the 300 Area in the vicinity of uranium fuel fabrication facilities and inactive waste sites. Total alpha and total beta concentrations in the 300 Area riverbank spring water from 1991 through 1996 parallel that of uranium and are likely associated with its presence. Strontium-90 was not analyzed for in 300 Area riverbank spring water in 1996.

Nonradiological Results for Riverbank Springs Water Samples

The range of concentrations of selected chemical compounds measured in riverbank spring water in 1993 through 1996 were presented in Table 4.2.5. With the exceptions of 1996 sample results for 100-F and 300 Area springs, nonradiological results in 1996 were similar to those reported previously. Samples from the 100-F Area springs, and to a lesser extent the 300 Area springs, had elevated concentrations of most metals and anions. The 100-F Area riverbank spring-water sample was collected below a steep bluff in the 100-F Area slough, where the spring water percolates through a deep layer of fine sediments. High suspended particulate loading in the 100-F

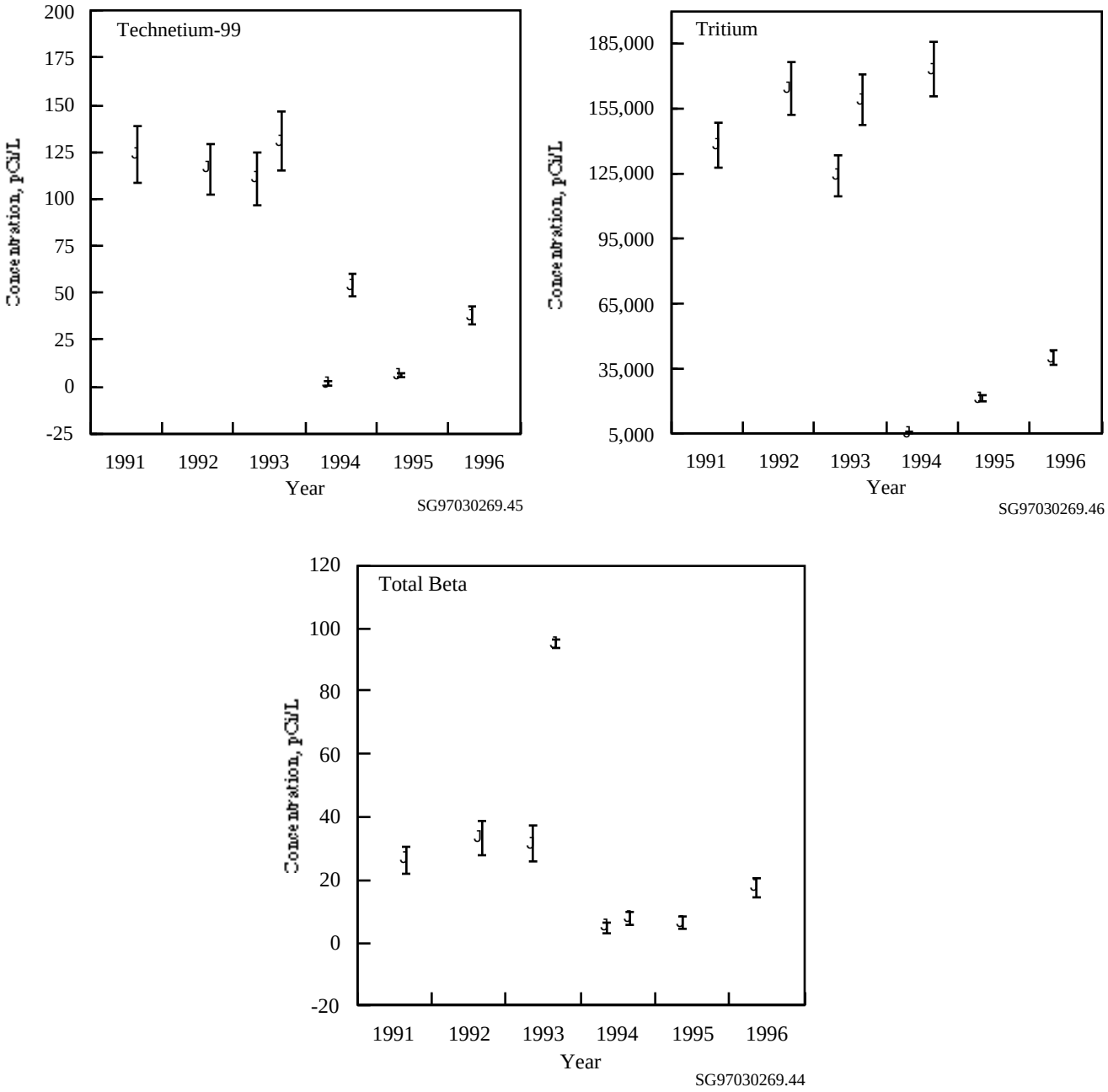

Figure 4.2.13. Concentrations (average ±2 total propagated analytical uncertainty) of Constituents of Interest in Riverbank Spring Near the Old Hanford Townsite, 1991 Through 1996. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.

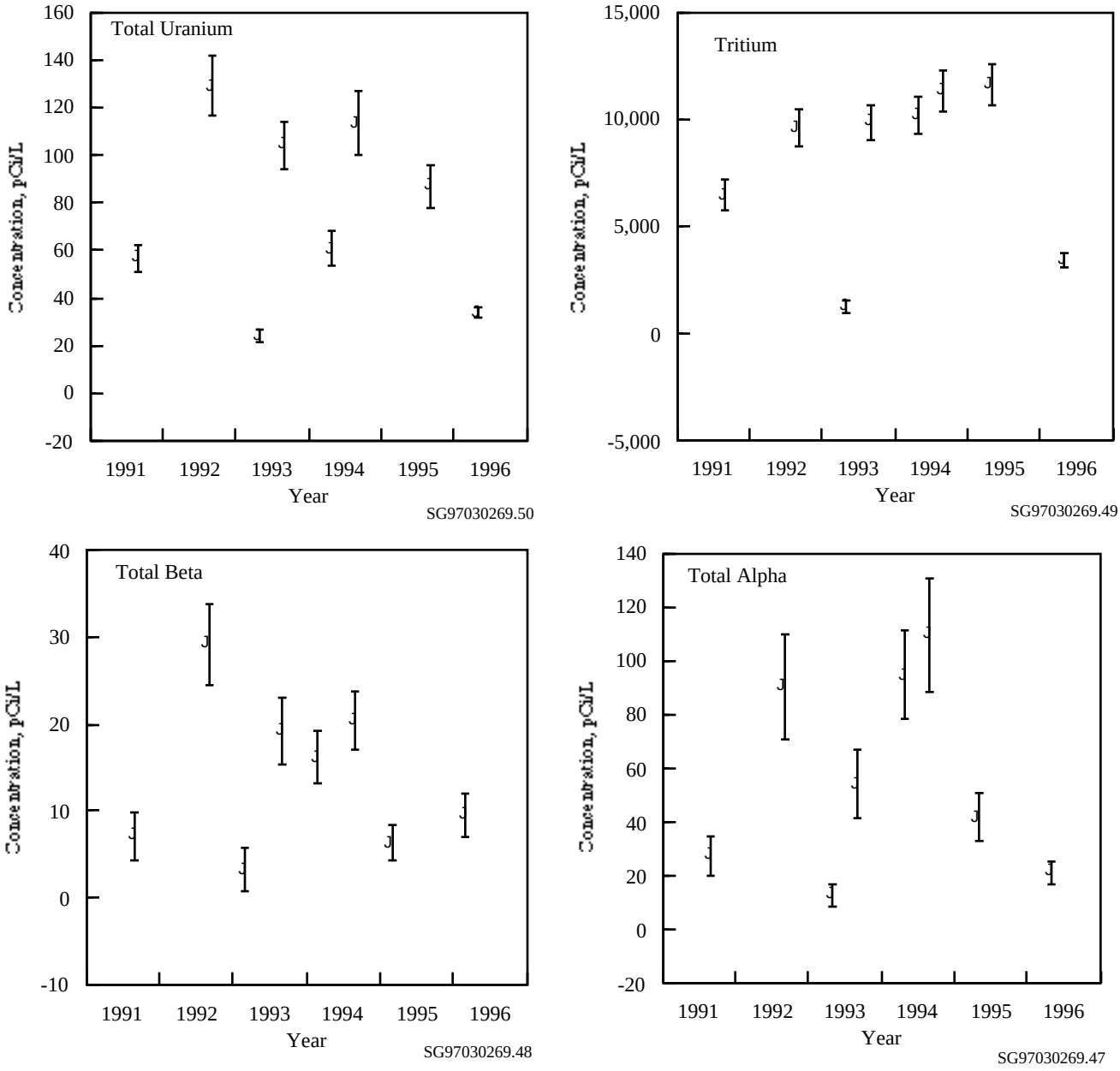

Figure 4.2.14. Concentrations (results ±2 total propagated analytical uncertainty) of Constituents of Interest in the 300 Area Riverbank Spring, 1991 Through 1996. As a result of figure scale, some uncertainties (error bars) are concealed by the point symbol.

Table 4.2.5. Concentration Ranges of Select Nonradiological Compounds in Columbia Riverbank Springs, 1993 Through 1996

	Ambient Surface Water Quality Criteria Level, µg/L	Concentration, µg/L							
		100-B Area	100-K Area	100-N Area	100-D Area	100-H Area	100-F Area	Old Hanford Townsite	300 Area
No. of Samples		4	1[a]	3	5	3[a]	3	4	3
Metals									
Aluminum		34 - 610	4,800	ND[b] - 9,400	66 - 180	27 - 88	41 - 20,000	67 - 940	140 - 3,100
Barium		55 - 64	120	32 - 140	34 - 80	27 - 48	41 - 270	43 - 54	95 - 120
Cadmium	[c]	ND - 0.72	2.0	ND	ND	ND	ND - 4.8	ND	ND
Chromium	[c]	21 - 25	66	ND - 45	ND - 400	18 - 55	6.0 - 99	ND - 2.5	ND - 6.4
Copper	[c]	ND	37	ND - 30	ND - 6.4	ND - 4.7	ND - 85	ND - 5.4	ND - 14
Iron		25 - 860	9,300	60 - 12,000	93 - 250	52 - 180	18 - 21,000	100 - 1,600	190 - 4,700
Manganese		1.9 - 22	330	3.2 - 680	6.6 - 27	7.6 - 11	3.1 - 470	7.1 - 82	5.8 - 220
Nickel	[c]	ND - 8.1	ND	ND - 25	ND - 26	ND	ND - 31	ND - 22	ND
Vanadium		ND - 11	33	6.6 - 42	ND - 5.3	ND - 3.6	ND - 59	ND - 19	ND - 4
Zinc	[c]	ND - 45	410	3.8 - 460	7.3 - 18	7 - 15	7.3 - 910	5.4 - 32	9.6 - 100
Anions									
Nitrate		7,600 - 11,000	15,000	3,800 - 15,000	1,000 - 46,000	27,000 - 47,000	20,000 - 33,000	5,000 - 40,000	6,600 - 23,000
Volatile Organics									
Chloroform	5.7	ND - 0.44 (5)[d]	ND - 0.79 (3)	0.75 - 3 (5)	ND - 4.1 (6)	3.7 - 14 (4)	ND	ND (5)	ND
Methylene chloride	4.7	ND - 0.49 (7)	ND (5)	ND - 1.3 (7)	ND - 1.2 (8)	ND - 1.2 (7)	ND - 1.2 (3)	ND - 0.52 (7)	ND (3)
Tetrachloroethylene	0.8	ND (4)	ND (3)	ND - 1.4 (4)	ND (5)	ND (4)	ND	ND (4)	ND
Trichloroethylene	2.7	0.52 - 1.0 (4)	7.4 - 9.5 (3)	ND (4)	ND (5)	ND (4)	ND	ND (4)	ND

(a) No samples were collected in 1996.
(b) ND indicates result was less than the minimum detection level.
(c) Ambient surface-water quality criteria level is hardness-dependent (WAC 173-201A-040; see Appendix C, Table C.3).
(d) Number in parentheses indicates number of samples used to calculate the range, if different from above.

and 300 Areas spring-water samples may be the cause of the elevated nonradiological results because these samples are collected unfiltered. Chromium concentrations were highest in the 100-D and 100-F Areas springs. Nitrate concentrations are highest in the 100-D Area and Old Hanford Townsite springs. Concentrations of volatile organic compounds were similar to previous years, with most below detection levels. Chloroform (100-B and 100-D Areas), trichloroethylene (100-B Area), and tetrahydrofuran (100-B Area) were the only volatile organic compounds detected in 1996. Hanford groundwater monitoring results for 1996 indicate similar levels of nonradiological contaminant concentrations in shoreline areas (Dresel et al. 1995).

Washington State ambient surface-water quality criteria for cadmium, copper, lead, nickel, silver, and zinc are total-hardness dependent (WAC 173-201A; see Appendix C, Table C.3). Criteria for riverbank spring water were calculated assuming the total hardness was attributable only to calcium and magnesium. Other multivalent cations typically comprise a small fraction of total hardness. Considering only calcium and magnesium in the calculations provided the most limiting surface-water quality criteria. The riverbank spring-water sampling protocol used did not lend itself to a direct comparison of most metal concentrations in riverbank springs to ambient surface-water acute and chronic toxicity levels because of different time frames (DOE 1994a). The standards are, instead, used as a point of reference. The ambient surface-water acute and chronic toxicity levels of arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc are 1-hour and 4-day average concentrations, respectively, not to be exceeded more than once every 3 years on the average (WAC 173-201 A-040). Riverbank spring samples are grab samples. Metal concentrations measured in riverbank springs from the Hanford shoreline in 1996 were below Washington State ambient surface-water acute toxicity levels (WAC 173-201A-040), with the following exceptions. Concentrations of copper in spring water were above acute toxicity levels in the 100-F and 300 Areas. Copper was not detected in other samples; however, the detection limit was above the chronic toxicity level. Cadmium was above the acute toxicity standard in 100-F Area spring water and similar to the chronic toxicity standard in the 100-B Area spring water. Chromium concentrations in spring water exceeded the chronic toxicity standard for the 100-B, 100-D, and 100-F Areas. Zinc concentrations were above the chronic toxicity standard in the 100-F and 300 Areas. Selenium concentration was above the chronic toxicity standard at the 100-F Area. The minimum detectable concentrations of silver exceeded their chronic and acute toxicity standards in 1996.

Riverbank spring-water samples were analyzed for chromium(IV) (i.e., chromium ion in the 6+ oxidation state) using an electroanalytical technique. Chromium(IV) concentrations were 67 to 70 µg/L in 100-D Area spring water, 32 to 34 µg/L in 100-F Area spring water, 20 µg/L in 100-B Area spring water, 5.2 to 5.3 µg/L in 100-N Area spring water, 1.2 to 1.4 µg/L in the Old Hanford Townsite spring water, and 0.6 to 0.9 µg/L in 300 Area spring water. The Washington State acute toxicity values for chromium (see Appendix C, Table C.3) were exceeded in the 100-B, 100-D, and 100-F Areas spring-water samples. Chromium concentrations in all other riverbank spring-water samples were below the Washington State chronic toxicity values.

The concentrations of all volatile organic compounds measured in riverbank spring water collected from the Hanford shoreline in 1996 were below Washington State ambient surface-water quality criteria levels. Because of low riverbank spring flow or evidence of bank storage, no sample was collected for volatile organics at the 100-K Area spring, where in previous years the concentration of trichloroethylene exceeded the EPA standard to protect human health.

Onsite Pond Water

Three onsite ponds (see Figure 4.2.1), located near operational areas, were sampled periodically during 1996. B Pond, located near the 200-East Area, was excavated in the mid-1950s and expanded in the 1980s for disposal of process cooling water and other liquid wastes that occasionally contained low levels of radionuclides. The Fast Flux Test Facility Pond, located near the 400 Area, was excavated in 1978 for the disposal of cooling and sanitary water from various facilities in the 400 Area. West Lake, the only naturally occurring pond onsite, is located north of the 200-East Area (Gephart et al. 1976). West Lake has not received direct effluent discharges from site facilities, but is influenced by the changing water table at the Hanford Site.

The site management and integration contractor is responsible for monitoring effluents discharged to the ponds and for operational surveillance of the ponds. Although

the ponds are inaccessible to the public and did not constitute a direct offsite environmental impact during 1996, they were accessible to migratory waterfowl, thus creating a potential biological pathway for the dispersion of contaminants (see Section 4.5, "Fish and Wildlife Surveillance"). Periodic sampling of the ponds also provided an independent check on effluent control and monitoring systems.

Collection of Pond Water Samples and Analytes of Interest

In 1996, grab samples were collected quarterly from B Pond, Fast Flux Test Facility Pond, and West Lake. Unfiltered aliquots of all samples were analyzed for total alpha and total beta activities, gamma-emitting radionuclides, and tritium. Samples from B Pond were also analyzed for strontium-90. West Lake samples were also analyzed for strontium-90, technetium-99, uranium-234, uranium-235, and uranium-238. Constituents were chosen for analysis based on their known presence in local groundwater and in effluents discharged to the ponds and their potential to contribute to the overall radiation dose delivered to the public.

Radiological Results for Pond Water Samples

Analytical results from pond samples collected during 1996 are given by Bisping (1997). With the exceptions of uranium-234 and uranium-238 in July and October samples from West Lake, radionuclide concentrations in onsite pond water were less than the DOE derived concentration guides (see Appendix C, Table C.5). Average annual total beta concentrations exceeded the ambient surface-water quality criteria level in West Lake. The average concentrations of all other radionuclides were below ambient surface-water quality criteria levels (see Appendix C, Table C.2).

Annual concentrations of selected radionuclides in B Pond for the years 1991 through 1996 are shown in Figure 4.2.15. B Pond comprises a series of four ponds: 216-B-3 (main pond) and the 216-B-3A, -3B, and -3C expansion ponds. Before October 1994, B Pond samples were collected from 216-B-3. However, 216-B-3 and -3A were decommissioned in 1994, and 216-B-3B was never active, though it did receive one accidental discharge. B Pond samples are currently collected from 216-B-3C. Contaminant concentrations found in samples collected from 216-B-3C in 1996 are similar to those found previously in 216-B-3. Average total alpha, total beta, tritium, strontium-90, and cesium-137 concentrations in 1996 were 17%, 18%, 0.42%, 4.1%, and 5.0% of ambient surface-water quality criteria levels, respectively. All other measured radionuclides were detected at concentrations greater than two times their total propagated analytical uncertainty in less than 25% of samples collected.

Figure 4.2.16 shows the annual total beta and tritium concentrations in the Fast Flux Test Facility Pond from 1991 through 1996. Median concentrations of both constituents have remained stable in recent years. However, the tritium concentration in the July 1995 sample was 16,400 pCi/L, which is much higher than that observed previously. During this time, backup water-supply well 499-S0-7 was in use. Tritium levels in well 499-S0-7 are typically above 20,000 pCi/L, reflective of those observed in a portion of the local unconfined aquifer. The use of backup water-supply well 499-S0-7 is most likely responsible for the high levels of tritium observed in July 1995 because the primary source of water to the pond is 400 Area sanitary water. Average total beta and tritium concentrations in Fast Flux Test Facility Pond water during 1996 were 23% and 25% of their respective ambient surface-water quality criteria levels. The concentrations of all other measured contaminants in this pond water were greater than two times their respective total propagated analytical uncertainties in less than 33% of samples collected.

The annual concentrations of selected radionuclides from 1991 through 1996 in West Lake are shown in Figure 4.2.17. Radionuclide concentrations in West Lake during 1996 were similar to those observed in the past. Total alpha and total beta concentrations in West Lake continued to be higher than levels found in the other onsite ponds. These elevated levels are believed to result from high concentrations of naturally occurring uranium (Speer et al. 1976, Poston et al. 1991). Annual median total uranium concentrations have remained stable over the last 6 years. The range in concentration, however, has shown a dramatic increase. Both the minimum and maximum annual total uranium concentrations have risen in recent years; the highest concentration occurred in summer and fall when the water level in the pond was low. It is believed that the relatively large concentration of suspended sediment in the samples is causing the elevated results. Similar total uranium concentrations were reported by Poston et al. (1991) for West Lake samples that contained high concentrations of suspended sediment. Declines in groundwater levels beneath the 200 Areas have been recorded since the decommissioning

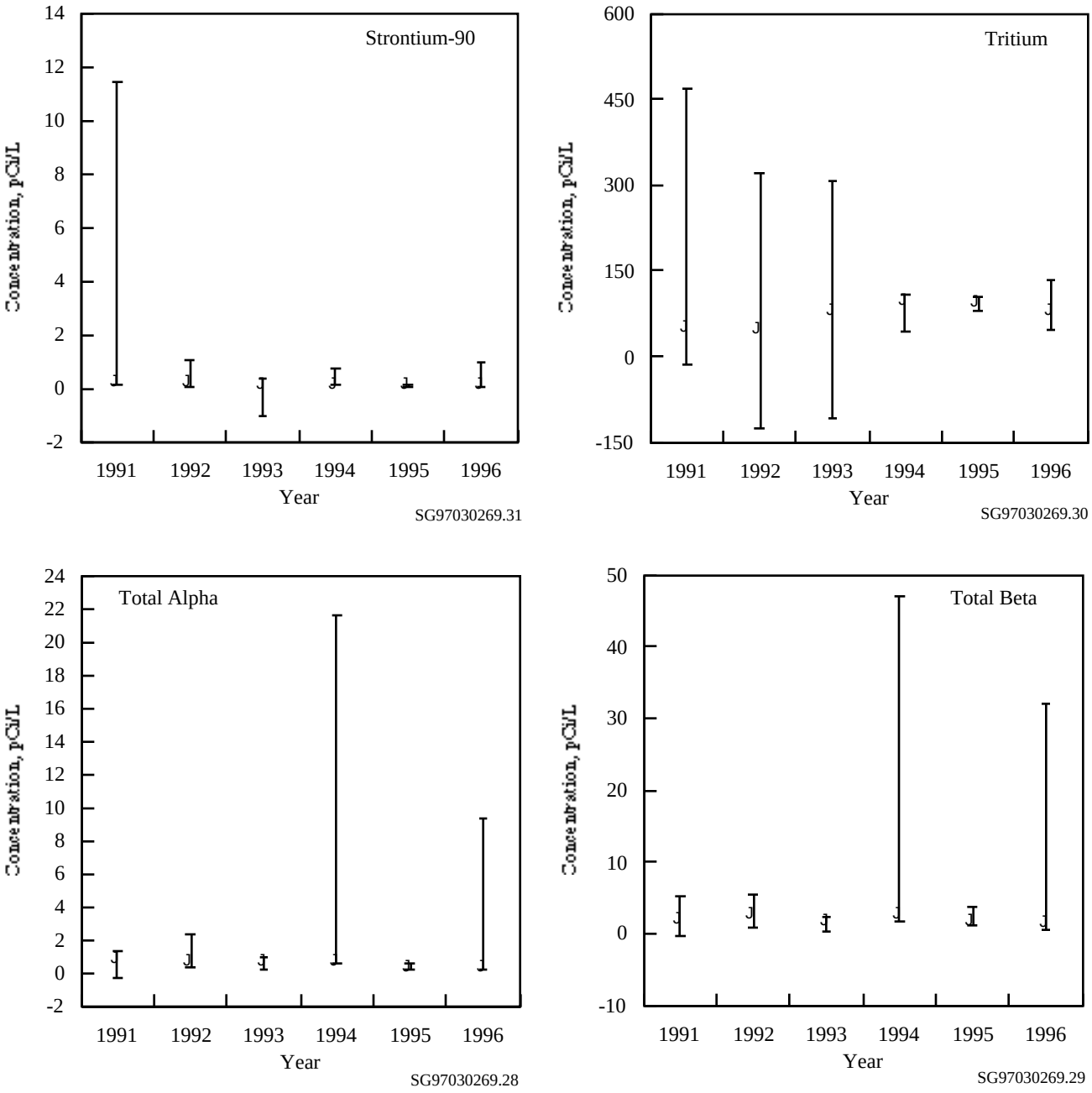

Figure 4.2.15. Minimum, Median, and Maximum Concentrations of Select Radionuclides in B Pond, 1991 Through 1996

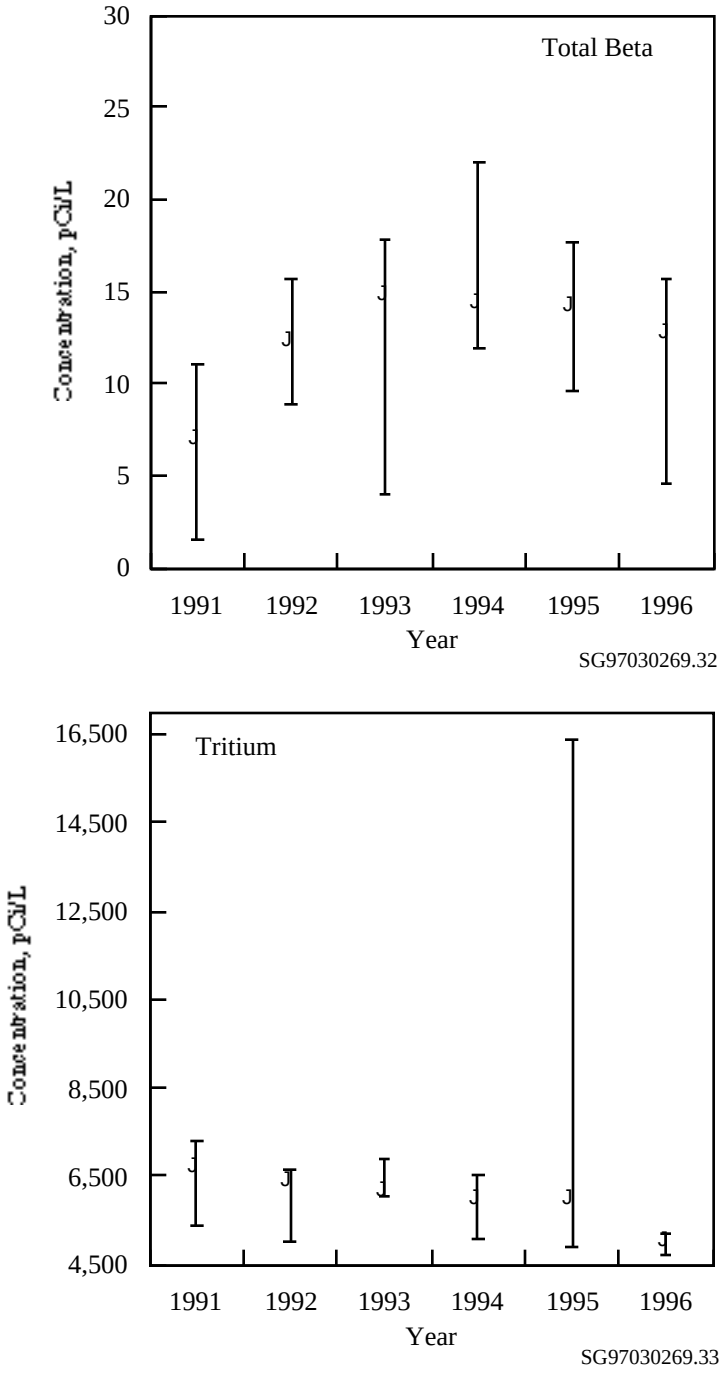

Figure 4.2.16. Minimum, Median, and Maximum Total Beta and Tritium Concentrations in the Fast Flux Test Facility Pond, 1991 Through 1996

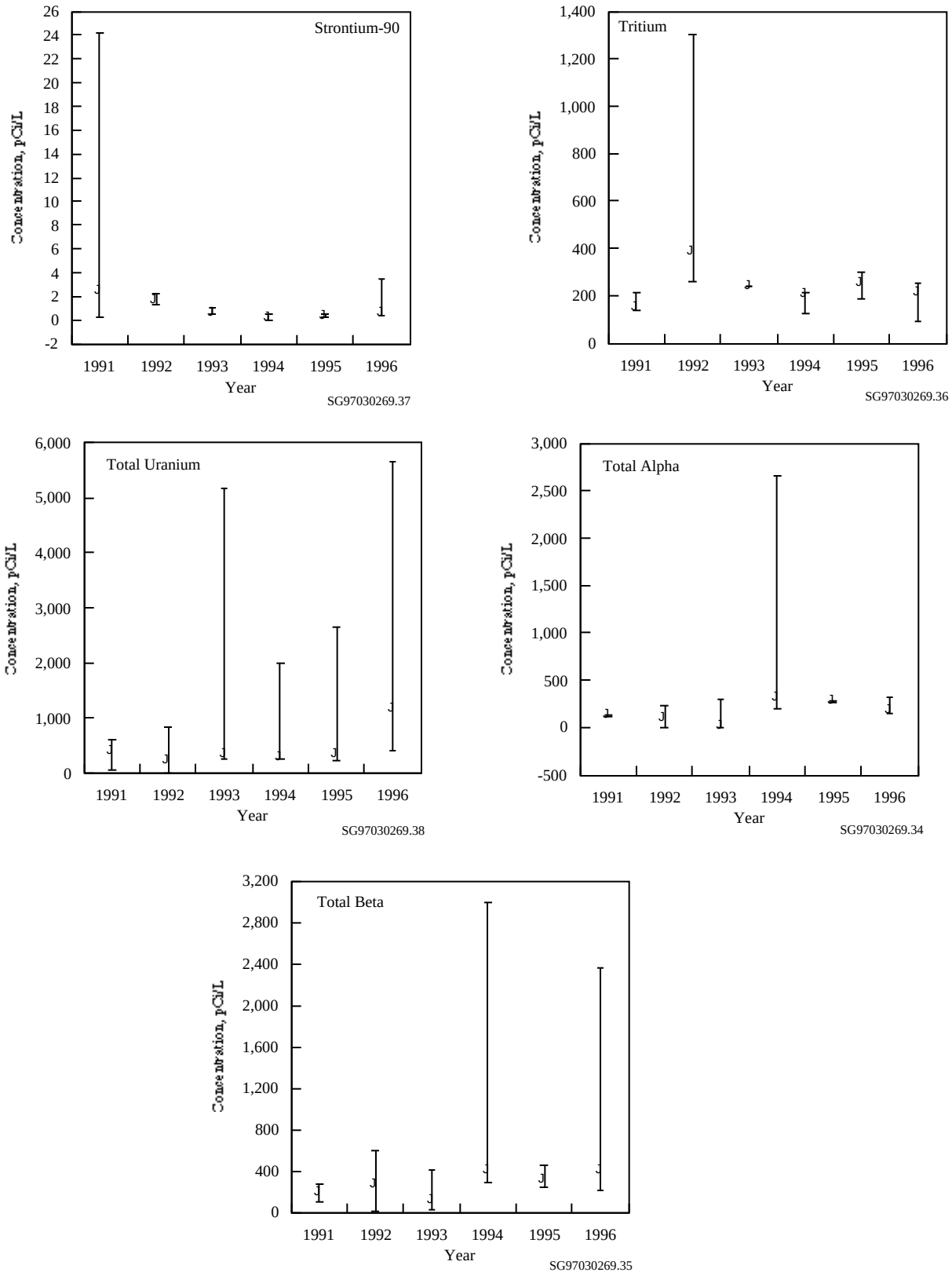

Figure 4.2.17. Minimum, Median, and Maximum Concentrations of Select Radionuclides in West Lake, 1991 Through 1996

of U Pond in 1984 and the shutdown of production facilities (Dresel et al. 1995). As a result, the water level in West Lake has dropped. Average concentrations of tritium, strontium-90, and technetium-99 in West Lake in 1996 were 0.96%, 18%, and 6.2%, respectively, of ambient surface-water quality criteria levels and were reflective of local groundwater concentrations. The concentrations of all other measured radionuclides were rarely higher than two times their associated total propagated analytical uncertainties.

Offsite Water

During 1996, Pacific Northwest National Laboratory staff collected and provided to the Washington State Department of Health water samples from five water supplies that utilized groundwater directly east of and across the Columbia River from the Hanford Site. Pacific Northwest National Laboratory did not analyze these samples for contaminants. Water samples were also collected from an irrigation canal downstream from Hanford that receives water pumped from the Columbia River, and these samples were analyzed by Pacific Northwest National Laboratory. As a result of public concern about the potential for Hanford-associated contaminants to be present in offsite water, sampling was conducted to document the levels of radionuclides in water used by the public. Consumption of food irrigated with Columbia River water downstream from the site has been identified as one of the primary pathways contributing to the potential dose to the hypothetical maximally exposed individual (Section 5.0, "Potential Radiation Doses from 1996 Hanford Operations").

Collection, Analysis, and Radiological Results for Riverview Irrigation Canal Water

Water in the Riverview irrigation canal was sampled three times in 1996 during the irrigation season. Unfiltered samples of the canal water were analyzed for gamma emitters, strontium-90, total alpha, total beta, tritium, uranium-234, uranium-235, and uranium-238. Results are presented by Bisping (1997). In 1996, radionuclide concentrations measured in Riverview irrigation canal water were found to be at the same levels observed in the Columbia River. All radionuclide concentrations were below the DOE derived concentration guides and ambient surface-water quality criteria levels. Strontium-90 was the radionuclide of most concern because it has been identified as one of the primary contributors to the calculated hypothetical dose to the public via the water pathway (Jaquish and Bryce 1989). The concentrations of strontium-90 in the irrigation water during 1996 ranged from 0.071 ± 0.039 to 0.13 ± 0.047 pCi/L and were similar to those reported for the Columbia River at Priest Rapids Dam and Richland Pumphouse (see "Columbia River Water" subsection).